

Astronomical Dialogues

Between a

GENTLEMAN

AND A

LADY:

WHEREIN

The Doctrine of the SPHERE,

Uses of the GLOBES,

And the Elements of ASTRONOMY and
GEOGRAPHY are Explain'd;

In a Pleasant, Easy, and Familiar Way.

With a Description of the famous Instrument
called the ORRERY.

By JOHN HARRIS, D. D. and F. R. S.

The SECOND EDITION,
Corrected by GEORGE GORDON.

L O N D O N:

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CERTIFICATE

OF

THE DOCTOR OF THE UNIVERSITY

OF

EDINBURGH



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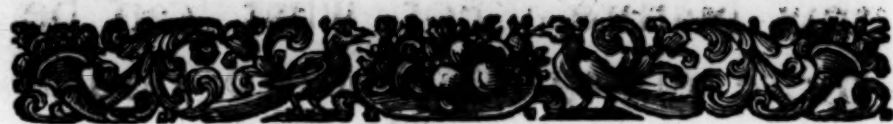
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TO THE
Lady CAIRNES.

MADAM,



THE Design of these *Dialogues* carries them naturally into the Patronage of the Fair Sex; so your own Merit, and my Duty, determine them to your Ladyship.

To you, Madam! who are blest with all those natural Graces and Genteel Accomplishments, which justly command universal Esteem; while Persons of true Taste and thorough Knowledge of Life, with Pleasure see even *those* ex-

The Epistle Dedicatory.

ceeded by intellectual Beauties, and such as claim Addresses of this Nature. For what can be more engaging than to find at Lady CAIRNE'S Table, the greatest Liberality and Elegance of Entertainment, outdone by improving Conversation, and the Understanding more regaled than the Senses?

But I know I must forbear; and not offend such a Modesty as your's, even with Truth: However, I can't help shewing that I am neither insensible of what all the World admires, nor ungrateful for the Obligations you have so generously conferr'd on,

MADAM,

Your Ladyship's

Most Humble Servant,

J. HARRIS.



T H E
P R E F A C E.

THIS Book was most of it written a good while ago : And being supposed to be lost for some Years, was lately retrieved, and reviewed by its Author, with the Disinterestedness of a Stranger. However, I liked it so well, as to resolve upon its present Publication, with some few Emendations and Additions. Of which latter sort the Description of the famous Orrery of Mr. Rowley, is the most considerable.

I wrote it in this diverting way, in pursuit of a Design, which, as I have made the general Business of my Life, so I can look back upon its Success with Pleasure, viz. The
en-

engaging Persons of Birth and Fortune in a warm Application to useful and real Learning: *To induce them to detach some of their happy Leisure from being lost by Sports, Play, or worse Avocations, and to dedicate it to the Improvement of their Minds.*

For I have often been ashamed and shocked to see, how awkwardly the few Modest have look'd, in Conversations where they could bear no part; and how insolently others have despised what they neglected to understand.

But what glorious Improvements might one expect from Persons of Fortune and Leisure, if they would addict themselves to these Things? who can bear the expence of good Instruments for Cælestial Observations.

For tho' there can hardly be above a Score in an Age who have pursued these Studies thoroughly; yet such great Lengths have been run in spite of all Disadvantages, as
may

may easily convince us, what to have hoped for, if Great Men would now and then divert themselves this way.

The Reader will easily see that the Conversation in these Dialogues is feigned, and in Imitation of Those of the Excellent Mr. Fontenelle, On the Plurality of Worlds. And that the Digressions, Reflexions, Poetry and Turns of Wit, are introduced to render Those Notions pleasing and agreeable, which perhaps without such a kind of Dress, would appear too crabbed and abstracted.

However, I don't perplex my fair Astronomer with any thing but the true System of the World : I mislead her by no Notions of Crystalline Heavens, or Solid Orbs : I embarrass her with no clumsy Epicycles, or imaginary and indeed impossible Vortices : But I shew her at first the Cælestial World just as it is ; and teach her no Hypotheses, which, like some other things taught at Places of great Name,
must

must be unlearned again, before we can gain True Science.

And as I think it practicable to explain and teach any Science in this Facetious way (Facetè enim & commodè dicere quid vetat?) so perhaps I may hereafter, if God grant me Health, Ease, and Leisure, make some other Attempts of this kind. For the Lady may well be supposed, tho' the sight of the Globes first struck her Fancy, and turned her Desires this way, to have made Excursions into other Parts of Mathematicks, and to have discoursed with her Friend on those Subjects. And perhaps all Those Dialogues may not be lost, as these had like to have been; but may, if these find a suitable Encouragement, be communicated also to the World.

*Multaque præterea tibi possum Commemorando,
Argumenta, fidem dictis contrahere nostris :
Verum animo satis hæc Vestigia parva sagaci
Sunt ; per quæ possis cognoscere cætera tute.*

Lucret. Lib. 1.



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BETWEEN A

GENTLEMAN *and a* LADY.

IT is now about seven Years ago, since I presented the most engaging Lady *M*.... with Mr. *Fontenelle's* Book of the Plurality of Worlds: And I remember well what she said a few Days after.

I have look'd over your Book, Sir, said she, as my way is, first *cursorily*, and I intend to give it a *very careful second Reading*; but I perceive by it, you have cut out much more Trouble for your self, than perhaps you imagin'd: For I find there are many things previously necessary to the understanding it, which you must oblige me with explaining; but, continued she, a Conversation of that kind with me, I doubt, will be too dull and tedious, since I am not bless'd with any of those shining Qualifications,
B with

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with which Mr. *Fontenelle* hath complimented M. *la Marquiese*; I should indeed, said she, except *those two*, which I suppose, in Complaisance to our Sex, he makes the Foundation of Philosophy, *viz. Ignorance and Inquisitiveness*; for those I'm sure, I have in Perfection, as you have long experienced.

I need not mention the Return I made, nor how prettily she changed the Discourse to something more general, when she found I was going to say just things of her; those that knew her, don't want to be reminded of the many Beauties, both of Mind and Body, which render'd Lady *M. . . .* one of the most agreeable Persons of her Sex; which yet, were she living, tho' a just Debt to her Merit, I must not have said, for fear of offending her Modesty.

ALL that is necessary to introduce what follows, is, to inform you, that some Years before her Death, when I went to visit that accomplish'd Lady at her Country Seat; I was a little surprized to find her, the next Morning after my Arrival, studiously viewing a pair of large Globes, which stood in the Drawing-Room, looking into the Garden, and which I used to make my Place of Study.

GOOD

GOOD Morrow, said I, Madam, what! hath *Fontenelle* made an Astronomer of you in good earnest? Are you really contemplating the Order and Motions of the Heavenly Bodies? Or are you rather seeking on the Earthly Globe, where to make new Conquests?

The Historians foolishly represent *Alexander* the Great, as weeping, that he could carry *his* no further than over all the World; but I'm sure, were he present now, to see you in that Posture commanding the *Globe*, and giving what Turns you please to it: that Thought of your humble Servant's would appear just enough;

*Had the Pellæan Chief thy Form but view'd,
With far more Haste he had the World subdu'd:
Proud at thy Feet to lay the mighty Ball,
Whose Eyes were form'd to triumph over all;
And then most justly had he wept to see,
One World too mean an Offering for thee!*

O! Sir, said she, your Servant, I doubt you did not rest well last Night? What did your Imagination carry you into the poetical Regions of *Fairy-Land*, that you awake with Verses in your Mouth this Morning? But to speak seriously,

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ously, I wonder you don't blush to paint so much beyond the Life, and yet suppose the Picture to be like any one; you affect to imitate our great Painters, if we sit to them, they make us all handsome; but they do it to shew themselves, not us, and they don't care so much whether it be like or no, so it be but a fine Picture; and in this our own Vanity too often indulges them.

But pray, added she, let us lay aside all these Fooleries; and be so good as to be serious with me for an Hour or two: I have a great mind to be let a little into the Knowledge of these Instruments, *the Globes*; and to know something of the first Principles and Rudiments of *Astronomy*; or else I find I shall lose half the Beauties of that very entertaining Book Mr. *Fontenelle's Plurality of Worlds*, which you formerly obliged me with, as well as perhaps be led into some Errors by it: And don't despise and neglect me, because I am a Woman. I have heard you sometimes say, you thought that there was no difference of Sexes in Souls; nay, that *our* Parts and natural Capacities were often *equal*, at least, if not *superior*, to those of Men. But perhaps there were some particular Reasons for your saying so then, which now altering or ceasing,

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ceasing, your Judgment and Opinion may have done so too.

I was going to assure her, that I was still of the same Sentiments, when putting on a forbidding Look, with a serious Countenance she proceeded thus :

THESE *Globes*, Sir, came too late to *Globes*. accompany a Relation of mine to *India*, his Ship having failed before they were finished, which is the Reason you see them here ; and I have ordered them to be set out this Morning, and shall do so from Day to Day, tho' without obliging you to what *Fontenelle* had with the *French Lady*, an *entire Week's Conference*. But I have a great mind to learn, from my Friend, something of the Nature and Use of them ; for they appear to be made and finished up with that *Curiosity* and *Care*, that sure some very useful Knowledge is to be learnt from them ; and is it not barbarous in you Men to confine it all to your selves ?

MADAM, said I, you will give me a new Rise to value any thing that I understand ; if I can render it acceptable to you.

B 3

WELL

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WELL then, Sir, said she, all Compliments apart, both to your self and me, pray let us go to our Business, the Tea won't be ready this Hour, and there is a little too much Dew for us to take a Walk in the Garden. Let me understand then; first the Difference between these two *Globes*, and why one hath the Cities, Countries, and Places of the Earth drawn on it, like a Map; and the other *Circles* and *Stars*, and these odd uncouth Figures of Beasts, Birds and Fishes: Pray why do they turn round? What doth this Brass Hoop signify in which they hang? For I perceive that it also hath Numbers engrav'd upon it: And what doth this *broad wooden thing* serve for, that hath the Days of the Month and other Letters, as well as Figures, pasted upon it?

I am glad, said I, Madam, by the warm manner of your Enquiry, to find that you are in earnest; and I have often wished that the same Curiosity and Love of Knowledge would inspire more of the Fair Sex, for it would mightily enlarge their Empire and Power over ours, by endowing them with more real and lasting *Beauties*, such as would improve with Time, and strengthen even in Age itself.

But

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But as to your present Questions, Madam, I will give you the most satisfactory Returns I can.

And first, Madam, it will be necessary to acquaint you with the meaning of the Word *Globe*; and what the Properties, in general, of such a Figure or Body, are.

Your Ladyship is to understand then, *Globe,*
that a Globe is a round Body of such a *what.*
Nature, that every Part of its Surface or Out-side, is at an equal Distance from one Point within it, which is called the Center. This Body also is sometimes named a *Sphere,* with regard to Astronomical *Sphere.*
Speculations; and this *Science* which you are now inquiring into, is hence called *The Doctrine of the Sphere.*

I THINK I understand you, said she, the Figure of a Globe is not flattish like that of a Cheese or a common Ninepin-Bowl; but rather like a Boy's Marble, or a Bullet cast in a Mould.

EXACTLY right, Madam, said I; and further you are to know, that a strait Line supposed to be drawn thro' the Center of this Globe any where, from one opposite Point of the Surface to the other, is called a *Diameter.* *Diameter.*

I THANK you, said she, for that Explication, Sir; I have often met with the Word, but never knew *fully* what Diameter signified before: But now I know what the ingenious Mr. *Butler* meant, when speaking of the Moon, he saith, that *Sydrophil* knew

*What her Diameter to an Inch is,
And prov'd she was not made of green Cheese.*

And now I know what the Plummer meant the other Day, when he talk'd of a Pipe of Lead of such a Diameter; I now know the meaning of *Diametrically opposite*, &c. But, pray, Sir, go on.

You will next see easily, Madam, said I, that if a Globe were at liberty, and any Power or Force at hand to move it, it would easily turn or roll round any one of its Diameters, as this Globe doth round this *Wire*; which particular *Diameter*, is called therefore its *Axis*; as being the *Axle-tree* on which it turns. But tho' this be true of the Nature of a Globe in general, yet the *Axis*, as we call it, of the Earth and Heavens, by the Will of our All-wise Creator, is one *fixed and determinate Line*; and about this the
fixed

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fixed Stars are usually supposed to revolve, without ever changing their Distance, or deviating from one another, or from it.

I AM mightily pleased, returns she, with the Nature of these *Globes*, because they are unbiassed and indifferent, as to this or that particular way of turning; and I fancy it to be a good Emblem of the Freedom of our Minds in the State of Innocence, when they first came out of Nature's Hands; they were then perfectly at liberty to move any way, which they lik'd best: and I dare say, that all the wrong Biasses and particular Turns that we find in any of them, are owing to the Weight or *Power*, as you call it, of our own corrupt Affections.

You moralize excellently well, said I, Madam, and are very just in your Notions of the Deity.

But she went on, and said; Yet I think we might be glad to receive from the first Mover and Author of all Things, such a *determinate Way of moving*, as you say God hath given to the Heavens and the Earth; for our own whimsical Motions, Turnings and Shiftings, seem to be as unaccountable as they are various.

BUT

Motion of the Heavens. BUT pray, said she, let me understand what you say as to the present Point a little further; Do the Heavens and the Earth all really move round about one *Axis*, as these two Globes do round theirs? And are the *Poles* thus beautifully described by Mr. *Dryden*, the two Ends of this *Axis*?

Poles.

*Two Poles turn round the Globe, one seen to rise
O'er Scythian Hills, and one in Lybian Skies;
The first sublime in Heav'n, the last is whirl'd
Below the Regions of the nether World:
Around our Poles the spiry Dragon glides,
And like a wandring Stream the Bears divides,
The Less and Greater, who by Fate's Decrees
Abhor to dive beneath the Southern Seas;
There, as they say, perpetual Night is found,
In Silence brooding on th'unhappy Ground:
Or when Aurora leaves our Northern Sphere,
She lights the downward Heav'n, and rises there;
And when on us she breathes the living Light,
Red Vesper kindles there the Tapers of the Night.*
DRYDEN'S Virgil.

Shall I ever come to know what these *Poles*, and *Dragons*, and *Bears*, mean?

VERY

VERY easily, Madam, said I, and you will find that the *Motion of the Earth* ^{*Motion*} *alone round its Axis* will sufficiently ac- ^{*of the*} count for all the rest; for these *fixed Stars* ^{*Earth.*} don't in Reality move at all, but only appear so to do. And you must know, that there is one Star, or a Point very near it, towards which this *Pole*, or End of the Earth's *Axis*, (which is called the *North-Pole*) doth always point: This is the Star here on this Celestial Globe, and if it be *PoleStar*. fair, and the Sky clear, in the Evening, I will shew it you in the Heavens: 'Tis said, by Astronomers, to be in the Tip of the Tail of the *Little Bear*, a *Constellation of Stars* so called; you see there are seven of these Stars in all, placed on the Globe within the *Picture* or *Figure of a Bear*: The Reason of the Figure I will tell you hereafter.

PRAY, said she, good Sir, don't take it amiss if I interrupt you with one Question: Is this *Tip* of the Bear's Tail, *that celebrated Tip* of *Cardan* the Conjuror; who, as *Butler* saith,

*Firmly believ'd great States depend
Upon the Tip of th' Bears Tail's End,*

I

That

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*That as she whisk'd it tow'rd the Sun,
Strow'd mighty Empires up and down.*

THE very same, Madam, said I.

Go on then, said she.

THIS Star here by the Wire, Madam, said I, we call the *Pole Star*, and the Point near it, thro' which the Wire runs, the *North Pole* of the World. And let the Earth be where it will, in its Annual Course round the Sun, this *North Point* on the Earth and here placed on the Globe, will always be either exactly or nearly under that *North Pole* Star or Point, in the Heavens. But of this more when I shall further explain to you the Motions of the Earth ; and this Position of the Earth's Axis is so firmly fixed and determined by the Author of Nature, that from it there hath never yet been observed any considerable Variation.

PRAY, Sir, said she, proceed : When I come to look over *Fontenelle* again, I perceive I shall understand him and you much better.

MADAM, said I, the outward Figures of these two *Globes* you see are nearly alike ; but tho' they are hung also, and fitted

fitted up alike, yet they are almost as different from one another in their Natures and Properties, as are the different Regions that they represent.

This Globe which is designed to shew *Terre-* the Face of the *Earth*; and which there-^{strial} fore is called the *Terrestrial Globe*, is truly ^{Globe.} and properly a Representation of it, round or spherical as that nearly is, and it hath the Sea and the Land, with all the Regions, Countries, Nations, Islands and Cities drawn upon it; just in that Order and Figure, that they are, in Reality, on the Face of the Earth itself; and it is, if carefully drawn, a true Map, or Description, of what is usually called *The World*: Whereas all those flat Maps and Charts, which you see drawn upon Paper, cannot be accurately so, tho' they are exact enough for common Use.

THAT Word *World*, said she, I can't get over without reflecting, what weak, vain, and silly Mortals we are: We too often take this *poor Spot of Earth* to be the only *World* worth inquiring after; and so we can but acquire a little of its Dirt, we neglect all Care for an eternal Mansion in the Heavens. And further, I have no patience with *Ptolemy*, I think they call him, and his Astronomers, that will needs have the

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mighty

mighty Sun, and all that infinite Orb of fixed Stars, to be made only for the sake of *this little dirty Planet*, as I remember somebody calls it ; and to have no other Use nor End, but only to dance round it, which yet, as I have heard, is a meer Point, and scarce visible to an Eye placed in some of the other Planets.

But to go on with my Lesson : Good Sir, said she, is the Figure of the Earth thus really round ? and have you any good Reasons to make you think so ? For I must own I had not till now a Notion of its being round like a Ball ; I took it rather to be round in Compass like a Dish or Plate.

Rotundity of the Earth. VERY many and substantial ones, Madam, said I ; and you will be fully convinced by them, when they occur to your reading hereafter, if you proceed on in that way you are now going : But, however, the Sun shining so bright into this Room, will furnish me *now* with one Argument to make that Notion plain to you. You see, Madam, when I hold any solid Body in this Light of the Sun, its Shadow will be nearly like the Shape and Form of that of the Body ; when I hold this Book in the Light, its Shadow will be

be square at the Sides, as the Book is ; but when I hold this Orange in the same Light, the Shadow, you see, hath a round Edge ; and therefore since in the Eclipses of the Moon, the Shadow of the Earth, which you know, Madam, occasions the Moon's being covered with Darknes, appearing always exactly round or circular, we justly conclude that the Figure of the Earth is round or spherical too, or else the Termination or Out-Line of its Shadow could never be always in a Circular Form.

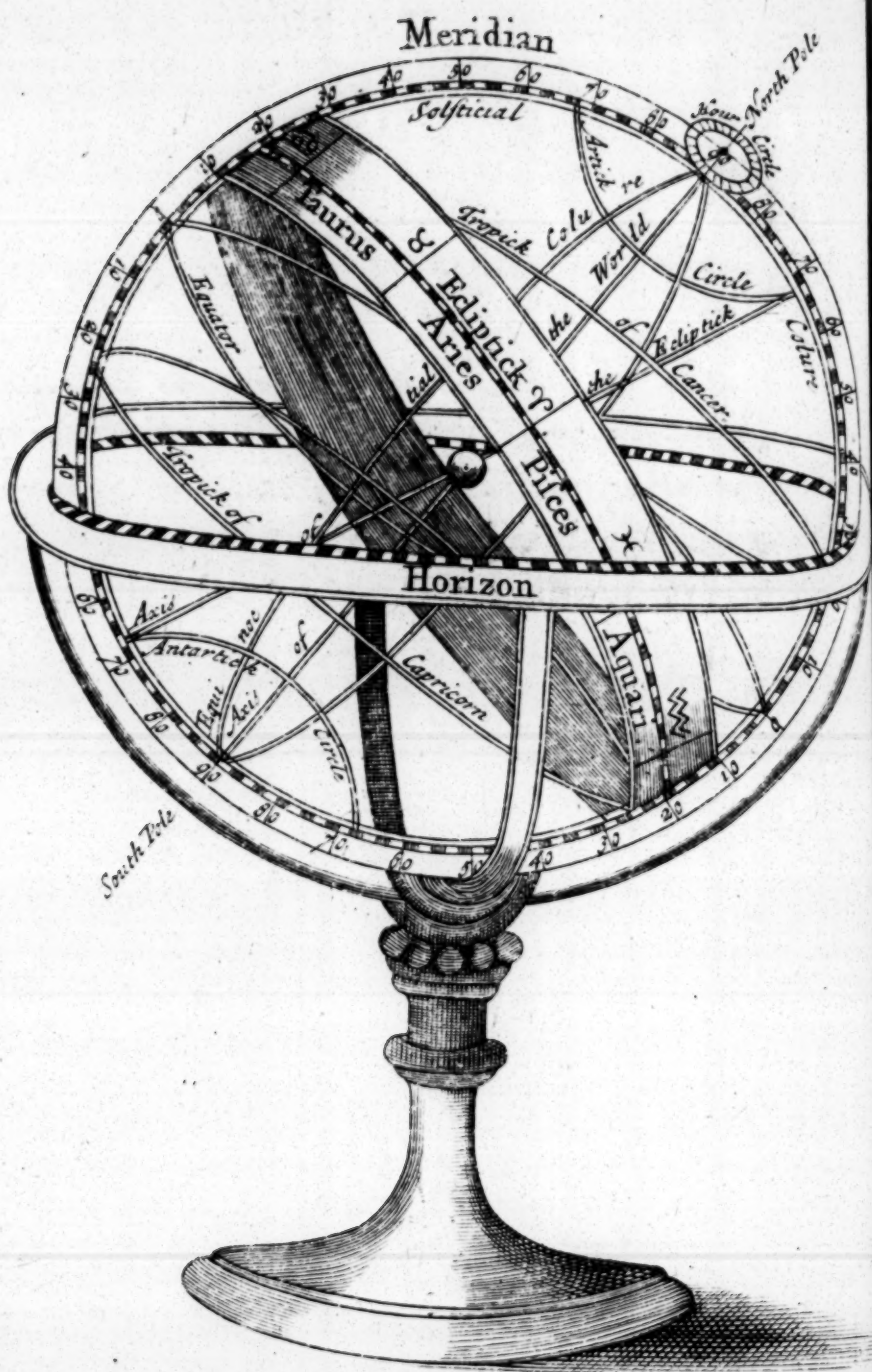
I THANK you for this easy and natural Explication, said the Lady, which I think I comprehend ; and I am beholden to the Sun, that great Fountain of Light, or rather to Him that made it, for being now instrumental to dispel the Darknes I had in my Mind before about this Affair ; however, being no *Persian*, I shall not worship the Sun for it. But pray, Sir, go on with an Explication of the other Globe.

THAT, Madam, is called the *Celestial* *Celestial* one, said I, because 'tis designed for a *Re-Globe*. *presentation of the Firmament, and the Concave Arch of the Heavens* ; and indeed it doth well enough exhibit to us the *fixed Stars*, and the Tracks or Circles of the

the Sun and Planets apparent Motions, if you get a right Notion of it, as this
Vid. Fig. 1. Figure, which we call an *Armillary* Sphere, will I think help you to obtain: In order to which you must now imagine your Eye placed within at the Center of the Globe, or on the little Ball there in the Figure which represents the Earth; and that the Spherical Surface of it, on which you see the Stars there painted and gilded, were transparent like Glass; so that you could actually see thro' it, not only all the *Circles* drawn upon it, but also all the Stars above in the Heavens, as they really appear there in a bright Night. And if you imagine further, Madam, that strait Lines were drawn from every Star in the Firmament to your Eye so placed, as before, in the Center of this Globe, those Lines would pass thro' and cut the Spherical Surface of the Globe in proper Points to paint, or to place the Pictures of the Stars upon.

I THINK, I conceive you right, said the Lady, so that if there were Holes in the Surface of this Globe in those Places where these Stars are painted upon it, and that my Eye were within at the Center, and the Globe turn'd, so as to conform itself to the present Position of the
Heavens

Fig. 1.



Heavens above; I should see every Star there thro' its corresponding Hole in the Globe.

YOU are perfectly right, Madam, said I, and *Ptolemy* himself, could not have expressed it better. And just in that Central Point (and just such a Point as that is it) do Astronomers of his Sect suppose Vid. Fig. 1. the Earth to be placed, as you see in the Figure, in the middle of the Sphere of the fixed Stars, which seem to revolve round about it, once in 24 Hours, because the Earth doth turn round her own Axis, tho' a contrary way, in the same Time.

OF this, replied *Clarella*, I have gotten a tolerable Notion from what you said before, and from the *French* Author: But, pray, let us now go on with our Globes here; What is the meaning of this *broad wooden Circle* placed round each of them, and what is it called?

MADAM, said I, it is called *The Horizon*; which is a *Greek* Word that signifies a *Limit* or *Determiner*. And to conceive it right, imagine your self placed, as before, on this poor little Earth, within that immense Celestial
C Globe;

Globe ; which you are to suppose now to be millions of millions of times greater than it really appears to be : Then you know, if you look round you on the Earth, its Surface will extend every way from your Eye, like a vast Plain ; which will be under your Feet, and to which your Body will be perpendicular or upright : This Plain stretching all round you every way as far as your Eyes can see, in a flat open Country where no Hills interpose : Or on the Surface of the Sea, will seem to divide or cut the concave Orb of the Stars, or the Sky, into two Parts (which they call *Hemispheres*) the one seemingly above this Plain, which therefore they call the *Upper*, and the other apparently below it, which therefore they call *the lower Hemisphere*. Such a Plain as this is call'd *the Horizon* : And if it be really that which any one's particular Eye makes upon any occasional View, 'tis call'd *the sensible Horizon* : But if you imagine this Plain, as you may easily do, to pass through the very Center of the Earth on the Surface of which you then stand, 'tis called *the real or rational Horizon* ; because that doth really or actually divide the Starry Regions into two equal Hemispheres ; and both these Horizons are well enough represented by that wooden Circle,

cle, which you now lay your fair Hand upon.

I HOPE I take you right, said she; and now begin to understand better the meaning of many Expressions which have often occur'd to me before, but with less Light. But why do you so cautiously use the Words *apparently above and below*?

BECAUSE, said I, Madam, there is in reality no such thing as any Difference between *above and below*: The Heavens are every where *above* or *without* what they contain; but we, taking our Ideas of things from ourselves, do agree to call that *above* or *uppermost* which is over our Heads, and that *below*, which is *beneath* us, or down under our Feet: And therefore as we call that *Concave* half of the Region of the fixed Stars, which we see above our Horizon, the *upper Hemisphere*; so the other half takes the Name of the *lower Hemisphere*.

I AM mightily pleased, said the Lady, with these Celestial Beings that are so perfectly above all the poor Trifles of *Place* and *Station*; with which we Mortals make such a bustle here below: Especially those of our Sex; as I will honestly

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own to you, now you are my Master and Teacher ; for as *Butler* hath justly observ'd,

*To us the Joys of Place and Birth
Are the chief Paradise on Earth :
A Privilege so sacred held,
That none will to their Mothers yield,
But rather than not go before,
Will forfeit Heaven at the Door.*

But let us go on. I perceive, said the Lady, that these Horizons will always vary as we shift the place of our View.

Y E S, Madam, said I, and so will the Hemispheres too that they determine.

A N D yet, said she, we are often so vain as to take our little narrow View or Horizon for the Bounds of all that is to be seen ; and judge, that what is not within our Hemisphere, to be either nothing at all, or at least not worth our knowing or enquiring after ; for we are always so vain as to despise what we do not understand. But I interrupt you with my impertinent Reflections ; pray, Sir, go on.

I B E G you to take notice farther, said I, Madam, that when the Sun, or any Star or Planet, appears at the Eastern Edge of
our

our Horizon, we say it is *Rising*; and when it has got quite above it, we say it is *Risen*, or is *Up*. On the contrary, if it appear towards the Western Edge of it, we say it is *Setting*; and when it is gotten below it, we say it is *Set*. And this *Rising* and *Setting* always respects the Sensible, and not the Real Horizon.

BUT what is the meaning of these Circles, demands she, which I see drawn here upon the Board of the Horizon, and on both Globes alike?

THE outermost of them, Madam, said *SeaCom-*
I, represents the *Points of the Compass*, *pass.*
as they are called by our Seamen; who make use of an Instrument called *the Compass*, to steer their Ships by at Sea.

PRAY let me know a little more of that matter, said she, for 'tis a Thing I have heard much talk of.

YOU have seen, no doubt, Madam, said I, a *Loadstone*; and know that it hath that wonderful Virtue, among others as strange, that if a Needle or long Iron-Wire be drawn rightly over it, that Needle will ever after that, when at liberty, *point*, as they call it, due North and South.

YOU are now, said she, so very good, that I think I must feed your Vanity, by owning, that I was once much pleased with some Verses of yours occasionally given me ; but am more so now, because I understand them better : after you had talked in your usual way of Love and Constancy, and I know not what ; you thus, as I remember, concluded,

*So when the Needle hath been once drawn o'er
The Loadstone's Poles, and felt its wondrous Power,
'Twill e'en in Absence keep its Truth and Worth,
And always point tow'rd its beloved North :
But when it once the Magnet's Presence gains,
With Joy it trembles and the dear Object joins.*

MADAM, said I, you do me and my Trifles a great deal of honour——

HUSH ! said she, not a word ! I won't now allow you one Syllable of Trifling ; be quiet and go on with your Lecture.

PLEASE to let me inform you then, Madam, said I, that such a Wire as this, so *touch'd*, as they call it, or directed by the Power of the *Magnet*, or Loadstone, they put into a round piece of Pasteboard, on which they draw a Circle ; dividing it as this on the wooden Horizon of the
Globe

Globe is, first into four Quarters, for East, West, North and South, placing the Point of North over that End of the Wire which will point that way ; then they divide each Quarter into Halves ; and by that means they make in the whole 32 Divisions, which they call *Points* ; and which are there and here expressed by the initial Letters of their Names after this manner : [See Fig. II.] And therefore the Use of that Circle on the Horizon of the Globes is to shew, on *what Point of the Compass* the *Sun*, or any *Star* or *Planet* apparently *Rises* or *Sets* ; as I shall shew you more fully hereafter.

WELL! saith she, I fancy my self half a Sailor already ; but for all that I must confess ingenuously to you, that I don't know how to find the Points of East, West, North and South in the Heavens, or on the Earth, unless I see a *Church*, which, they say, usually stands East and West.

MADAM, said I, that is easily known, by the Noon-day, or Meridian Sun ; for the Sun at Twelve a-Clock being always full South, when you turn your Face towards it, the North will be on your Back, the East on your Left, and the West on your Right-hand.

THAT'S true, said she ; but as obvious as this Observation is, I never made it before. And really the Education of us Women, is so silly and cramp't, that, generally speaking, we are never taught, nor enured to think of any thing out of the common Way, and beyond the Legend of the Nursery : Nothing but our *Work*, a little *Houswifery*, and a great deal of *Gossiping*.

But pray let us go on : The next *Calendar* circle I perceive is only an Almanack, with both our Own, and the Foreign or New Stile, or way of accounting Time : But pray, Sir, of what Use is this innermost Circle, and how is it divided ?

Divisions of a Circle.

MADAM, said I, all Circles on the Globes are supposed to be divided into 360 equal Parts, which they call *Degrees*, and each Degree into 60 lesser Parts, which they call *Minutes*, and so on, by a Sub-division by 60 still, as far as you please. This Circle is design'd to shew us what we call the *Sun's Place* for every Day in the Year ; and therefore is divided actually into 12 Parts, which are distinguish'd here, you see, by these Pictures of 12 eminent Constellations, or Parcels of Stars ; and which, because they do *sign*
or

or mark out a *particular Place* in the Heavens, where the Sun is, or appears to be, every Month, have been called the *Twelve Signs* of the Zodiac: And each of these *Signs* of the Zodiac is divided into 30 equal Parts or Degrees, which makes up the whole 360. *the Zodiac.*

HOLD a little, Sir, said the Lady, for I have now so many things to ask you, that I know not where to begin——

MADAM, said I, all the Affair of the Zodiac, of the 12 Signs, and of the Sun's apparent yearly Motion through them, I will fully explain to you hereafter: And all you need know now is, That it is the Use of this Circle to shew you in what Degree of it, or in *what Place* or Part of any of the 12 *Signs*, in which the Sun is supposed to be at Noon, answers to each particular Day of the Month. As for instance; You see this Day, *May* the 20th, is placed in the Calendar, just against the first Degree of (Π) *Gemini*, and therefore that is the *Sun's Place for this Day*.

SINCE I must wait, said she, I will be patient, and be content to be taught in your own way; but I will never forgive you if you don't tell me, *just now*, why 360 was *only* pitch'd upon for the Number of Divisions,

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Divisions, or, as you call them, *Degrees of your Circles*; and why any other Number would not have done as well?

MADAM, said I, any other *greater Number* that could have been broken into *Parts without Fractions* would have done better. But they had a particular Reason to pitch upon this of 360, which yet I beg you will excuse me from telling you now, because it will be much more usefully explain'd hereafter, and save a great many Digressions at present.

WELL! said she, I'm sure you keep me out of this only to mortify me, and to try my Patience; but that I may not tire *yours*, I submit.

YOU are so moderate and easy in your Desires, Madam, reply'd I, that I will now go out of the common Method, and explain all that matter to you immediate-

*Sun's
Motion.*

The ancient Astronomers observed of the Sun, that besides his apparent Motion round the Earth in 24 Hours, by which he made, as they supposed, Day and Night; the former when he was above, the latter when he was below the Horizon of any place; which daily or *diurnal*

nal Motion (by the by) they supposed to be always made either in this very Equinoctial Circle, or in some other lesser ones parallel to it, or equally distant from it: These Parallel Circles also they supposed to be, in the Summer half-year on the *North-side*, and in the Winter on the *South-side* of the Equinoctial. And they took notice, Madam, that besides this Diurnal Motion (which appear'd to be circular) the Sun had also in appearance a progressive one, *forward* on in another circular Track in the Heavens; which, because they found that when ever the Moon came into the very same Circle, there would be an Eclipse of either *Her*, or of the *Sun*, they call'd the *Ecliptick*. This is the Circle here on the Globe, which lies oblique to, or *askew*, and cuts or crosses this other, which is drawn exactly in the middle between the Poles, and is call'd the *Equinoctial* or *Equator*: This Ecliptick Circle also, because they perceived that the Sun never deviated from it in his Annual Motion towards either Pole North or South, they called the *Way of the Sun*: And they found that in the Time of our Common Year, he would appear to go quite round, or pass successively through all the Parts of this Circle.

B U T,

BUT, said the Lady, how could they determine that? For when the Sun was above the Horizon, no Stars at all could be seen, to distinguish his Place or Situation by.

YOUR Objection is just, said I, Madam, if you consider the thing *after* the Sun was actually Risen, and just *before* his Setting: But they took notice of those Stars which were at or near the Edge of the Horizon *before* his Rise, and such as were there *after* his Setting; and found that the Sun would not continue to rise and set always at the same distance from the same Stars; but if, for instance, on *March* the 10th, he would rise and set near these Stars which you see here placed on the Globe within this Constellation called *Aries*, about a Month after they found that he would rise and set with those in *Taurus*, which lie a 12th part of the whole Circle more this way, or forwards on, as the Numbers shew, to the Eastward: and after this manner the Sun proceeding still forward every Day, they found that at the end of 12 Months he would seem to have gone entirely round in this Circle, and to rise and set successively with or under all the Fixed Stars,
which

which are in or near this Circular Tract called the *Ecliptic*.

BUT, pray, Sir, said she, what do you mean by *under* the fixed Stars? Why, don't the Sun move *in among* them, and along with them?

NO, by no means, Madam, said I, the fixed Stars are probably farther, a long way, from the Sun, than that mighty Luminary is from us; and the meaning of the *Sun's Place*, or his being in such a *Sun's Sign*, is only his being for such a *Time Place* under that Star or Constellation, or between that and our Eyes; so that if a Right Line were drawn from that Star to your Eye, it would pass thro' the Center of the Sun.

I BEGIN, said the Lady, I think, to comprehend this a little better than I did; but, pray, Sir, what is the meaning of the Word *Zodiac*, which you used a while *Zodiac* ago, when you began to talk about the Sun's Motion?

THE ancient Astronomers, Madam, said I, to distinguish these Constellations, or *Setts of Stars*, under which the Sun constantly appeared to move in his Annual

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nual Course, gave them particular Names: The first they called *Aries*, or the Ram; the second *Taurus*, or the Bull, &c. and because these Names were mostly taken from *Animals*, or living Creatures, they called it the *Zodiac*; which is a *Greek* Word expressing such a Collection.

WELL, said she, as for your *Greek*, I know nothing of the matter, but now I begin to find out the Justness of those Lines, in *Hudibras*; wherein he describes *Sydrophil's* Surprize at the Discovery of his new Star, occasion'd by a Lanthorn at the Tail of a School-Boy's Kite:

'Tis not among that mighty Scrowl,
Of Birds, and Beasts, and Fish, and Fowl,
With which like Indian Plantations
The Learned stock the Constellations.

And these, I suppose, are the Pictures, continu'd she, of those *animated Stars*, or rather, as *Butler* hath it in the same Place, the *Signs of Those*:

Nor those that drawn from Signs have been,
The Houses where the Planets inn.

MIGHTY well remember'd, said I,
Madam, you see at once why the Astro-
nomers

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nomers call them the *Twelve Signs*, because, as I said before, they *sign* or mark out the Place of the Sun in the Heavens; and also why the Astrologers called them *Houses*, because they assigned them as *Dwellings* or Places of Abode for the Planets.

O! said she, now you talk of Astrology, I must ask you a few Questions about *that* either now or some other time; for I long to know whether there be any thing in that Art or no; for I think I have heard you throw out some suspicious Words about it.

MADAM, said I, if you please to go on with your Astronomy, you will soon know enough to despise that vain and foolish Cheat, as a thing perfectly beneath your Enquiry into.

VERY well, said she, and so if I will be an Astronomer, it seems, I must at once bid adieu to that darling Pleasure of our Sex, Curiosity, and the Desire of knowing our Fortunes; this is very hard, and you are really, Sir, a very bad *Woman's Man*; you have philosophized me out of many a fair Pleasure already; Censure, Satyr and Gossiping are almost gone; and must dear *Inquisitiveness* follow them
too?

too? It shall never be, let it be never so silly; I remember what *Butler* saith:

*Doubtless the Pleasure is as great;
Of being cheated, as to cheat;
As those receive the most Delight
Who least perceive a Jugler's Slight;
And still the less they understand,
The more admire the Slight of Hand.*

But I ha'n't time to quarrel with you, and to dispute it out with you now; pray, therefore, Sir, go on, about the Sun's Motion, a little farther.

You must know then, Madam, said I, that these venerable Star-Gazers, finding the Sun apparently to run thro' this Zodiac, in twelve Months, or a Year's time, assigned one part of the Circle to a Day's Motion: and because there are but a few more than 360 Days in a Year, they supposed this Circle of the Sun's Annual Motion, to be divided into 360 equal Parts, which they called *Degrees*, as I told you before; and hence all Circles on the Globes came to be divided after the same manner.

I thank you, Sir, said she, now this Matter begins to clear up to me; have
I you

you any thing more to teach me about this Circle?

ONLY the Explanation of a few Terms, or Words, which you will find used about it, said I, Madam: For you must know, that the Astronomers call the Distance of the *Sun's Place* at any time of the Year, from the Beginning of *Aries* here, which you see is placed at the Eastern Point, where this Circle of the *Ecliptick*, and that of the *Equinoctial* cross one another, they call that Distance, I say, his *Longi-Sun's tude*; and tho' the Sun himself apparent-^{Longi-}*tude*ly moves always in one Circle, exactly in the middle of the *Zodiac*, that is in the *Ecliptic*, yet the Moon, and the other Planets, do not, but sometimes are 5 or 6 Degrees to the North, and at others, as far to the South of this Circle; and this Deviation or Distance they call their *La-Planets titude*; and you shall be shewn hereafter ^{Latitude.} how to measure it; and the same Word is used also, with reference to those fixed Stars which are not in the *Ecliptic*, but are distant from it, any way, towards either of its Poles; for the Distance of a fixed Star from the *Ecliptic*, is also called its *Latitude*.

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BUT

BUT, pray, Sir, said she, is not the Word *Latitude* used also with Reference to the *Terrestrial Globe*? Surely I have heard my Brother speak of *Peking* in *China's* lying in such a *Latitude*; of the *Latitude* of *London*, and of his Ship being harassed by a Storm, in such a *Latitude*; but I must own I never knew the meaning of it: Am I Astronomer enough to be taught that now?

YES, Madam, said I, and you will very easily comprehend it: Please to turn your Eyes to this *Terrestrial Globe*; this Circle which lies exactly in the middle, between the two Poles of the *Equator*. Earth, is here called the *Equator*, and by the Sailors *the Line*; all Places which lie under it, or which have the Equinoctial in the Heavens, passing over their Heads, are said to have no *Latitude*; but all *other Places* that lie at any Distance from it, either North or South, are accordingly said to have North or South *Latitude of Places*. *Latitude*: And its Quantity is known by turning the Globe about till the Place come to this *Brazen Circle* in which the Globe hangs, and there *the Place* will shew its own *Latitude*, in Degrees upon that Circle: Thus, you see, Madam, when

when I bring *London* to this Brafs Circle, it appears to lie on the North Side of the Equator, in $51\frac{1}{2}$ Degrees distant from it.

MIGHTY well, Sir, said she, I now conceive what *passing* or *crossing the Line* is, which I have heard the Sailors make such a Fuss about; and I have read of strange Ceremonies and Duckings, which they make young Navigators undergo, at the first time of their *crossing the Equator*: I perceive now, also, the true meaning of several Allegorical Expressions, which, no doubt, are taken from hence, such as being a *Latitudinarian in Notions*, &c. But pray, Sir, let us go on; now you mention that *Brafs Hoop*, in which the Globes hang and turn round, pray let me know its Name and Use?

THAT Brazen Circle, Madam, said I, *Meridian* is called the *Meridian*; and 'tis a greater^{an} Circle of the Sphere, which is supposed to pass thro' the *Zenith* and *Nadir* of any particular Place, thro' the North and South Points of its Horizon, and thro' the Poles of the World.

I SEE, said she, the latter part of what you say; but pray, what do you mean
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by the Terms *Zenith* and *Nadir*, the former of which Words I have often met with in Books, but never knew the meaning of it.

'TIS an *Arabic* Word, said I, Madam, and signifies that Point in the Heavens that is directly over your Head, as *Nadir* doth the opposite one in the lower Hemisphere, that is under your Feet, at the opposite End of a Diameter of the Earth: And this Brazen Circle is called the *Meridian*, because, whenever the Sun comes to the Meridian of any place on the Earth, in his daily Course, 'tis then, what the *Latins* called *Meridies*, i. e. *Mid-day*, or exactly *Noon* there.

O ! Sir, said she, this *Astronomy* is mighty instructive ; I now understand the just meaning of such Expressions, as these,

*There Vice did in its Zenith reign,
Our bright Meridian Sun decline, &c.*

But pray let me know the Use of this Circle here on the Globes.

I shew'd you just now, said I, Madam, That on the *Terrestrial Globe* it shewed the *Latitude* of all Places, which, by being brought successively to it, as the
Globe

Globe turns round its Axis, do each receive it for their own Meridian, for 'tis all one as if a different Meridian had been actually drawn on the Globe thro' every Place.

No doubt on't, said she, for 'tis the same thing, *as to meeting*, whether the Mountain walks to *Mahomet*, or he stalks to the Mountain: But methinks this *Earthly Meridian* is either very lazy, or else takes great State upon him, that all Places must come to him, while he stands and struts here, and won't stir the least Step towards them. — Have you any thing more to tell me about this *Man of Brass*; *Spencer* did wisely to make his *Man Talus* of Iron, that was to be *Arthegall's* Page, and to bear so busy and active a Part in his Story.

MADAM, said I, this Brass Meridian serves also, by its moving thus, round, North or South, in this perpendicular Situation to the Horizon, to elevate or raise ^{Height of} the Pole of any Place as much above its Horizon in Degrees, as is the Latitude of that Place, or its Distance from the Equator; and then that particular Place will be brought to lie in the Zenith, or uppermost Point of the Globe.

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PRAY

PRAY explain this by an Instance, said she.

I SHEWED you just now, said I, that the *Latitude* of *London* is found by the Help of this Meridian to be $51^{\circ} \frac{1}{4}$; raise therefore the North Pole so, that the Northern Edge of the Horizen cut $51^{\circ} 30'$ of this Brass Meridian, reckoning from the Pole, and then *London* will be in the Zenith Point of the Globe.

I SEE it is, said the Lady, and I believe I see also the Reason why it must be so; for it is just as far (*viz.* 90°) from the Equator to the Pole, as from the Zenith to the Horizon; so that taking away the middle Part, which is common to both, the *Latitude* of any Place, and the *Height of the Pole* above its Horizon are all one in Quantity; and so I suppose 'tis called the *Height of the Pole*, because the *Pole Star*, which is near the Polar Point (as I think you told me) will appear, in the Night, just so high above the Horizon of any Place, as is that Place's Latitude.

EXCELLENTLY explain'd, Madam, said I, and yet I fancy you want to be told further, that the Height, or *Altitude of the*

the Pole Star, as well as *all other Altitudes* of the Sun or Stars, is taken by an Instrument, which hath a circular Edge like this graduated Meridian, divided on Purpose into *Degrees, Minutes, &c.* with Sights fitted to it, to look up at the Object.

I WAS just going to ask you about that, said she; for I remember to have often seen you peering up at the Stars, or catching the Sun-Beams with just such a kind of thing as you describe: But, pray, what Use is this Meridian of, on the Celestial Globe?

THERE, Madam, said I, it shews the *Declination* of the Sun or Stars, by bringing the Sun's or Stars Place in the Ecliptic on the Globe to it, as we did the Places on the Earth upon the other Globe, to find their Latitudes.

Declination! said she, there's a *new Sun's De-*
Word for me to learn! which, I suppose, *clination.*
the Astronomers have coined, to avoid that of *Latitude*; which, when it relates to the Stars or Planets, I think you told me regards the *Ecliptic* only: Well! I doubt my Head will never retain the Memory of all these *Cramp Terms*.

YES, Madam, said I, very easily, when you so perfectly understand their meaning, for we only forget what we understand but by Halves; things thoroughly known become part of our Nature, as it were; and People can also generally remember what they have a mind to. But, however, if you please to look over Dr. *Harris's* little Book of the Globes, you may have your Memory refresh'd at any time very briefly, and yet plainly and fully.

I THANK you, Sir, said she, for that Information; I shall, I hope, be able to understand a little of Books of this Kind, by Degrees: But, pray, have you any thing more to shew me, relating to these Circles?

MADAM, said I, 'twill be proper for you to know, that as our Astronomers make *six greater*, so they make also *four and lesser* Circles of the Sphere; two of which they call the *Tropicks*, and the other two the *Polar Circles*. The meaning of the Word *Tropicks* is, *returns back again*; for indeed neither the Sun seemingly, nor the Earth really, goes any further in its Annual Course, to the Northward or Southward of

of the Equinoctial than 23 Degrees and $\frac{1}{2}$; but after it hath gone so far, *returns* again toward it: And because the Points in the Heavens, where these Returns are made, are under the Beginning of the Signs $\text{\textcircled{c}}$ *Cancer* and $\text{\textcircled{w}}$ *Capricorn*; they suppose two Circles to be there drawn in the Heavens and on the Earth, parallel to the Equator; and the most Northern of these, and which therefore is our Summer *Tropick*, is called the Tropick of *Cancer*, and the Winter, or Southern one, *that* of *Capricorn*; because they always fall at the Beginning of those Signs.

I LIKE our Earth mightily, said she, for her Steadiness in her Way, and for her not going too far North or South towards the Poles: I love moderate Weather, and would have it be in neither of the Extreame of Heat nor Cold: But, Sir, this matter now begins to clear up to me apace; when the Sun is in the Northern Tropick, I see our Days are at the longest, and all of them longer than our Nights, during the time of his whole Stay on the North-side of the Equinoctial: Whereas the very Reverse, I see, must come to pass, while the Sun is on the Southern Side of the Line. But, pray, of what Use

Polar Circles and Tropicks. Use are the *Polar Circles*? for I see they are drawn on both Globes, as well as the *Tropicks*, and just as far from the Poles as the *Tropicks* are from the Equinoctial.

OF no very necessary Use, Madam, said I, but only to help to distinguish the Terrestrial Globe into the five Parts, which the Ancients called *Zones*, and which they fancied to be like so many *Girdles* or *Belts* (as the Word *Zone* signifies) encompassing the Earth.

Zones. O PRAY, said she, let me have some true Knowledge about these *Zones*, for I have heard and read a good deal of them, without being a Jot the wiser.

Torrid. THE great Space on the Earth, said I, Madam, which lies between the two *Tropicks*, having the Equator 'passing thro' the middle of it, the Ancients called the *Torrid*, the *Fiery* or *Roasted Zone*; for they fancied the Sun, keeping always over it, had such a Power here, as to have burnt all things up; and because they had no Knowledge of it, concluded it not inhabitable; whereas 'tis now known to be very comfortably so: Tho', no doubt, warm enough to those Inhabitants of it to whom
the

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the Sun is successively vertical, or directly over their Heads, as you easily see by the Globe he will be.

YES, yes, said she, I understand that very well; but I can't help reflecting upon the *Arrogance*, as well as Ignorance, of the Ancients, in supposing *their* Knowledge to be the Bounds of all things; and glad I am that *we* know something which they did not; for I have heard them so much cried up, now and then, by Authors, that I could almost wish myself to have lived among them; but I will, at last take Comfort, and thank God that I am a *Modern*, and alive now.—But pray go on about your Zones.

THESE two Spaces of the Earth, said I, Madam, which lie between the Tropicks and the Polar Circles, each Way North and South, the old Geographers called the *Temperate Zones*; and as these *Temperate*. Oriental Sages, and the Learned *Greeks and Romans*, lived (as you (a) see here) in *one* of them, so they did allow the *other* to be habitable also.

(a) Here on the Terrestrial Globe I shewed her the chief Places of the *Gracian* and *Roman* Empires.

THAT was pretty good-natur'd, said she, for I suppose they never saw the South-

Southern *Temperate Zone*, any more than the *Torrid* one.

Not that we can find by History, said I, Madam: But to proceed; These small Spaces of the Earth, between the Polar Circles and the Poles, they called the *Frigid Zones*, and did pretty justly suppose them not to be habitable, upon the account of their Coldness; for tho' we have since discovered, that 'tis possible to subsist, and several of our Ships do yearly go within the Northern Frozen Zone, yet I can't recommend it to you as a Place much worth your Enquiry after.

O! don't speak any more about them, said she, you make me shiver all over with the Thought of them, and my Blood is just going to curdle in my Veins; no *Lapland* or *Spitsburghen*; no Whale-Fishing Voyages for me.

You seem to be really a-cold with the Thought of it, Madam, said I; let me warm you a little with this Description of these Zones given by Mr. *Dryden*.

From VIRGIL and OVID.

Zones. *Five Girdles bind the Skies: The Torrid Zone
Glows with the passing, and repassing Sun;*

Far

Astronomical Dialogues.

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*Far on the Right, and Left the Extreame of Heaven,
To Frosts, and Snows, and bitter Blasts are given;
Betwixt the midst, and these the Gods assign'd
Two Habitable Seats for Human Kind;
And cross their Limits cut a sloping Way,
Which the twelve Signs in beauteous Order sway:
And as five Zones the Ætherial Regions bind,
Five correspondent are to Earth assign'd;
The Sun with Rays directly darting down,
Fires all beneath, and frys the middle Zone:
The two beneath the distant Poles, complain
Of endless Winters and perpetual Rain:
Betwixt the Extreame two happier Climates hold,
The Temper that partakes of Hot, and Cold.*

WELL, said she, these Verses have a little recovered my Spirits, as well as refreshed my Memory, and will, I find, fix in the latter, the obliging Pains you have taken to instruct me: But pardon me, Good Sir, if I stop you a Minute: Mr. *Dryden* here mentions the Word *Climates*; *Climates*. Pray what are they?

MADAM, said I, you will find a deal of useless Stuff in some Introductions to Geography, &c. about these *Climates*; but all that is necessary to know of them, is, that the Ancients supposing two Circles to be so drawn parallel to the Equator, on *Parallels*. the Terrestrial Globe, or at that Distance

one from another, that to such as inhabit the *lesser*, the longest Day, would be a Quarter of an Hour longer, than it is to those who dwell in the *larger*: Then the Space on the Globe, between these two, they called a *Parallel*, and the Double of such a Space a *Climate*; you will easily see therefore, that these Climates must lessen as you go each way from the Equator to the Poles, and must be 24 in Number.

WELL! said she, I shall not trouble my Head about reckoning these *Climates*; but I think I understand what is meant by such a Place lying in such a *Climate*, as well as what the Navigators mean by sailing in such a *Parallel*, and that will be enough for me at present; but I will tire you no longer now, I'll get the Book you advise me to, which I believe I have above among my Brother's things; and after I have conned my Lesson well over, you must expect that I shall ask you abundance of Questions more.

WITHIN a short Time after this, the Ingenious and Inquisitive Lady got her Globes set out again, and began with me thus:

I have been looking over the little Book you recommended to me, Sir, said she, which I think is very plain and concise, and I fancy I am now got to be such a Proficient, as that I am qualified to go thro' the *Problems*, as the Book calls them, *Problems.* tho' what that Word signifies I don't understand.

THAT Greek Word, Madam, said I, signifies *something to be done or practised*, and I question not but you have so well considered this Affair, as to be able to work or perform any of these *Problems* upon the Globes yourself.

I don't know that, said she, but I'm resolv'd to try, and with a little of your Help, perhaps, I may get thro' them: Come, pray, let's begin; and, *first*, shew me how to *rectify* each Globe, as he calls *Rectify-* it, and what I shall learn by that. *ing the*
Globe.

Rectifying the Globes, Madam, said I, is reducing them to such a Position, as that they shall truly represent the Situation of the Circles of the Sphere of the fixed Stars, and Planets; and of the Position of the Earth itself at any Time assigned.

VERY well, said the Lady, let us then take his Time of the Year ; suppose *May* 10, 1719 ; How must we begin ?

*Sun's
Place.*

MADAM, said I, for common Use, look first for the Sun's Place, against the Day of the Month, in the Calendar, on the wooden Horizon (tho' if you would proceed to greater Exactness, you must find the *Sun's Place* in some good Tables, such as those which Dr. *Harris* hath given in the second Volume of his *Lexicon*, or such as *Parker's* Almanack, which I have here in my Pocket, gives you every Year, or else you must determine it by Calculation, &c.) and then finding that Place, or what Degree of any Sign of the *Zodiac* the Sun appears to be in that Day at Noon, which you will find to be then in the first Degree of *Gemini*, look it out on the *Ecliptic* on the Globe, and there make, either with a Pencil or with Ink, a Mark to represent the Sun for that Day.

BUT, said she, won't that spoil the Globe ?

No, Madam, said I, *that* being varnish'd, the Ink will easily come out again, if you rub it with your Handkerchief a little

little wetted; as soon as this is done, you may also, if you please, by the Help of *Parker's* or some such *Ephemeris* or *Astronomical Diary*, place *all the Planets* on your Globe, after the same manner, allowing for their Latitude, either North or South of the Ecliptic.

Thus the Moon being then in $24^{\circ} 33'$ of *Cancer* ☊, and having about $4^{\circ} 41'$ of South-Latitude, take, with a Pair of Compasses, those Degrees and Minutes of Latitude from the Meridian, or any great Circle, and placing one Foot in $24^{\circ} 33'$ of ☊, turn the other directly towards the Equinoctial, and there make this Mark ☾ to represent the Moon.

After the same Method you may place ♄ *Saturn* in $8^{\circ} 42'$ of *Virgo* ♍; and ♃ *Jupiter* in $26^{\circ} 35'$ of *Leo* ♌: Then make also this Mark ♂ for *Mars* in $16^{\circ} 32'$ of *Aquarius* ♒: And this Character ♀ for *Venus* in $28^{\circ} 18'$ of *Gemini* ♊: Lastly, placing ☿ *Mercury* ☿ in $11^{\circ} 4'$ of the same Sign, you will have adorn'd your Globe with the Characters of the Seven Planets, all appearing in their proper Place as they are in the Heavens.

THIS is mighty Entertaining, said she; here take this Pencil quickly, and let me
E sec

see you just now place all your Planets upon the Globe according as they ought to be done, that I may learn how to range them another Time: For I fancy their very *Characters* or Figures so much, that I could almost wish our Patches were cut into such pretty Forms; but that I fear 'twill revive the foolish Notions of Astrology again, which you have taught me to despise. But, pray, continued she, how do you know the Planets from the fixed Stars when you see them in the Sky?

PRETTY easily, said I, Madam, as to *Saturn, Jupiter, Mars, and Venus.* And *Mercury* is so near the Sun, as to be very rarely seen at all.

THAT puts me in mind, said she, of what Sir *Richard Blackmore* saith of him in his *Poem* call'd *Creation*, in these Lines:

*Mercury, nearest to the Central Sun,
Doth in his oval Orbit circling run;
But rarely is the Object of our Sight,
In Solar Glory sunk, and more prevailing Light.*

WELL remember'd, Madam, said I. But to our present Point, the Knowledge of these Planets from the fixed Stars: The former, you must know, don't *twinkle* as
the

the fixed Stars do; besides they are always and all of them in or near this Line here called the *Ecliptic*: Which you may easily learn to trace out in the Heavens, by these Constellations which compose the Twelve Signs; and if you should, at last, doubt about the *Planets*, if you see them change as they will do, in some Time, their Distance from any fixed Star that you know; you may easily distinguish them to be *Erratics* or Planets.

I think, said she, you reckon'd seven Planets just now; sure I have read somewhere, that there are more.

IN that Account above, said I, Madam, I followed only the vulgar way of Computation, for in Reality the Sun is no Planet or Wanderer, but a fixed Star placed in the Center of our System, *Number* and in all Probability like the rest of *of Planets* those that we see in the Heavens. And round him, as a Center, *Mercury, Venus, Mars, the Earth, Jupiter, and Saturn,* do revolve, and are now called *Primary Planets*; because they revolve round the Sun, as their Center: While the others we call *Secondary Ones* or *Satellites*, i. e. Guards or Attendants, because they revolve round some one of the *Primary Planets*,
E 2 nets,

nets, as their Center, and together with it, move also round the Sun.

*Satel-
lites.*

Thus the Moon is a Secondary Planet, whose Center of Motion is our Earth, on which she constantly attends, and her Circle round us she performs in about a Month's Time, while at the same time, she revolves together with the Earth round the Sun in its Annual Course. *Jupiter* hath four such Moons or *Satellites*; and *Saturn* five, revolving round him: But it doth not yet appear that *Venus* or *Mars* have any *Satellites* at all.

As for *Mars*, said the Lady, I shan't trouble my Head about him; tho' one would think, the God of War, or Captain-General of Heaven, might command a few Guards or Followers: But I will never forgive the Astronomers, nor believe at all in Telescopes, if they don't find out that *Venus* hath some *Attendants*; that is such an Affront to our Sex, as we must never pass by. But to be serious, I suppose, *Mercury* and *Venus* being so near the Sun, have no occasion to be lighted in the Night by Moons, as the more remote Planets have; tho' why our Earth should have one, and yet *Mars* none, is not, methinks, so easy to be accounted

counted for. But we have made a long Excursion from our Globes ; pray let's return to them : And let me see what I shall be the better for knowing how to *rectify* the Globes, and to *patch* on the Planets, as you just now have shewed me the way of.

MADAM, said I, bring the *Sun's Hour-Place*, for *May 10*, to the graduated Side *Circle* of the Meridian, and then turn or set the *Index* of the Hour-Circle (placed here as *and Index*) upon the Brass *Meridian* about the Pole) to Twelve at Noon ; and then your Globe will be fitted to shew you the State of the Heavens. As it now stands, the Mark for the Sun represents his being on the Meridian, as he is every Day at Noon ; and there it will shew the Sun's *Meridian Altitude* above the South Part of the Horizon to be *58 Degr. 42 Min.* Then if you will bring that Mark to the Eastern Edge of the Wooden Horizon, you will see there *what Point of the Compass* the Sun rises upon, and your *Index* will shew you the Time of it ; and if you bring the Sun's Place to the Western Edge, you will find how far from the true West Point the Sun sets, and what a-clock it is when he *goes down*, as we call it : Thus, *May 10*, the Sun rises about $\frac{1}{4}$ of

an Hour before 5 a Clock; and sets $\frac{1}{2}$ of an Hour after 7.

WELL, said she, I fancy I shall be able to make an Almanack in a little Time.

THAT you may soon do, this way, said I, Madam, and much better than most of those who publish them: But if you have a mind to know the Stars and Planets, how they will appear, and are situated at any particular Time, suppose to-night at Eleven a-Clock; you need only turn the Globe about till your *Hour-Index* points to Eleven at Night; and then putting a little Piece of Paper under the Bra's Meridian, to stay the Globe in that Position, please to turn the Frame, and Globe and all, about, till the North-Pole here point up towards the *Pole-Star* in the Heavens; and then you will have all you can wish for shewed you: for, by comparing the Pictures and Marks of the Stars and Planets with the real ones, at that Time in the Heavens, you will find them exactly to answer to one another; and *these* on the Globe will make *those* easily and sufficiently known to you.

SIR, said she, after abundance of Thanks, I must beg you to break off here;

Astronomical Dialogues.

55

here ; we must defer this till Night :

*When with the Stars we'll be familiar,
As e'er was Almanack Well-willer.*

And in the mean time, I'll con my Lesson in the Book, that my Ignorance may not give you too much Trouble. The Tea waits us ; will you please to move, Sir ?

THE Evening of this Day proved one of the finest I ever saw, and the Night succeeding it was so very clear and bright, that the Moon being then not above our Horizon, there appeared many more Stars than usual. As we were walking to a Summer-House, placed on a Mount in the Garden, where the Lady had order'd the Celestial Globe to be set out, several Poetical Descriptions of such a Night occurred to our Thoughts, and were recited. The Lady closed all with that famous one of Mr. *Dryden*,

*All things are hush'd, as Nature's self lay dead,
The Mountains seem to nod their drowzy Head,
The little Birds in Dreams their Songs repeat,
And sleeping Flowers beneath the Night-dew sweat:
Even Lust and Envy sleep——*

I was going to say——*But Love denies, &c.*
E 4 when

when she interrupted me, and said, I'll have nothing of *Love* mention'd nor talk'd of to-night; the Opportunity is too solemn, and I'm afraid I shall grow in earnest and serious about it: We will both make our Court now only to *Urania*, and every *gay thing* shall give place to *Astronomy*: Let's enter the Summer-House, and see whether I have rectified the Globe as it should be, and set it right to represent the present Time, which is just half an Hour past Ten.

MADAM, said I, you have done it with Accuracy: And I see you have mended the hasty clumsy Figures, that I had made, of the Planets, and have placed very beautiful ones, of your own, in their Room.

BUT, said she, I don't know how to place the Globe due North and South, as my Book directs, unless there were a little Compass here, placed on the Frame.

MADAM, said I, there usually is such a Compass made on purpose to be placed on the Globe; but I can shew you how to set the Globe right enough without it; you
Charles- see these 7 large Stars here, that are painted
wain. within the Figure of the greater Bear, 3
 in

in the Tail, and 4 in his Body: These our *English* Country-People call *Charles-Wain*, and fancy the *four* to be the 4 Wheels of the Waggon, while, forsooth, the *three* are to represent the 3 Horses that draw it. But as to the present Concern, please to take notice, that as this Constellation, in our Horizon, *never sets*, but seems to revolve round the Pole in 24 Hours; so these two Stars of the 7, that are nearest to the Pole Star, or the two hinder Wheels of the Wain, do always *point* up pretty nearly to the Pole Star; and are therefore sometimes called the *Pointers*; and consequently, if you carry your Eye on in a Right Line from them, they will direct you to the *Pole Star*, which you see is here, on the Globe, placed in the End of the Tail of the *Lesser* ^{*Lesser*} *Bear*, a Constellation of 7 pretty large *Bear and* Stars, much in the same Figure of those in *Pole Star*. the *Great Bear* or *Charles-Wain*.

I SEE them on the Globe, said she, let us now look out of the Window and observe them in the Heaven; O! I see them yonder very plain, said she, and now I shall know in the Night as well as the Day, how to find the four Points of the Compass, *East, West, North, and South*.

WE

WE must then return again to the Globe, Madam, said I, and by opening the North Window, direct its Pole to point up to the *Pole Star*, and so set it as near as we can due (a) North and South.

(a) Here the Brass Meridian of the Globe was placed due North and South.

There is no need of great Accuracy for our present Purpose; and I think it stands pretty true now.

Before we look or go out again, pray, Madam, please to observe this Situation of the Globe, and then you will easily see how the Position of the Stars do at present correspond with it: There is, indeed, now not any very eminent Star, or one of the first Light or Magnitude, *exactly* on the Meridian, either North or South: But you will see this great Star, which is called the *Virgin's Spike*, because painted on an Ear of Corn which she holds in her Hand, a little to the Westward of the South, and about 28 Degrees high above the Horizon; as you see, appears by bringing this Quadrant of Altitude screwed in the Zenith, to it; which is an Arch of 90°, and being moveable, serves to shew the Altitude of any Star or Planet.

Spica Virginis.

I SEE that, said the Lady, *here* on the Globe: But how shall I be able to find and count Degrees in the Heaven?

YOU

YOU know, Madam, said I, that it hath been before observed to you, that the Astronomers have Instruments made on purpose for it, which do it with great Accuracy: But as for your present Enquiry, how high any Star or Planet appears to be above the Horizon, you may guess at it nearly, thus: The Distance you see here between the *two Pointers* of the *Great Bear* before-mentioned, is nearly five Degrees; and this being a Distance always ready, and in view, will serve you very well to guess at the Height of any Star above the Horizon; or at the Distance of one of them from another; so as to enable you to find out any of them in the Heavens by the Help of the Globe, or any Planisphere, or Map of the Heavens: Use will make this easy to you; and when you come also to consider, that from the Zenith to the Horizon, being 90° , half that Distance must be 45° ; one third of it 30° ; a sixth of it 15° ; a ninth part of it 10° , &c. you will, by Degrees, easily gain a practical Knowledge of these Distances.

But if you please we will go on: Almost South-west, at this time, and about 43° high, will appear another Star of the first Magnitude, called *Deneb*, which is in *Deneb.*
the

the Tip of the Tail of the Lion ? I see it yonder simpering thro' that Western Window ; if you will let me lift up the Sash, you may see it without going out.

O ! I do, said she, and the Virgin's Ear of Corn too, very plain : But what are those two great Stars that appear together almost nearly West, and let me see ! — don't tell me — about, about — I must look out at the *Pointers* again to get my Measure — why, they are about 25 Degrees high.

VERY well guess'd, said I, Madam ; you will come to measure the Distance of Stars by your Eye, in a little time, as accurately as the good Housewives and Workwomen can measure Cloth or Ribbons, by the length of their middle Finger.

WELL, said she, Mr. *Observer*, and so I can too, for all I have a mind to be an Astronomer, as well as the best of them ; and I don't design, Sir, that my Studies shall spoil my Housewifry : But pray tell me quickly, who those two famous Stars are.

THE uppermost, Madam, said I, is *Cor Leo*— called the *Lion's Heart*, and is, you see, *nis.* drawn here on the Globe: And the other is *Jupiter*; you remember you have drawn the Character of him here your self.

BLESS me! said she, is that *Jupiter*— well, I have many Questions to ask you about that Planet another time, but I will not stop you now; pray go on, and shew me how to know more of these Stars and Planets; for I begin to grow mighty fond of their Acquaintance.

DON'T you see, Madam, said I, here on the Globe, two Stars, about 15 or 16 Degrees high, and within two Points to the Westward of the Northern Edge of the Horizon: These two are called the Shoulders of *Auriga*, and the lowermost and most Northern is called *Capella*, and *Capella* is a Star of the first Magnitude; these are very conspicuous Stars, and you may see them in the Heavens very plain out of that Northern Window.

I DO, said the Lady, very clearly, and I see, said she, also another pretty remarkable Star, about the same Height
with

with *Capella*, about a Point to the Northward of the West, under the *Great Bear*; pray, what Name do you give him?

THAT is called *Pollux*, Madam, said I, and his Brother *Castor*, you see, sit here close by him on the Globe; and between them they make up one of the Signs of the *Zodiac*, which they call *Gemini*, or the Twins.

Is that, said she, the Deity that the Countrywomen swear by, when they cry *O Gemini!* — But don't look grave, or give me any Return: For tho' I trifle, and am impertinent, I won't allow you to be so. Let us go on and see what noble Stars we can find to the Eastward of our Meridian.

MADAM, said I, if you will look out at that North Window, and direct your Eye along by the Pointers of the *Great Bear*, till you see past, or beyond, the *Pole Star*, and continue it down till you come within 20 or 30 Degrees of the North North-East Part of the Horizon, you will see an eminent Constellation which is called *Cassiopeia's Chair*: This is the Figure of it here on the Globe; 'tis always

always opposite to the greater Bear, either above or below the *Pole Star*.

I SEE it, said she, very plain, and a very notable Collection of Stars it is; but, pray, said she, what do you mean by calling it *Cassiopeia's Chair*? Who, or what *Cassiopeia*. was that *Cassiopeia*? sure I have read something about her, in some Books of the Heathen-Gods.

No doubt of it, Madam, said I, and the Company you will see she is in, will refresh your Memory. This *Cassiopeia*, the Poets tell you, was the Wife of *Cepheus*, *Cepheus*. who was, once upon a time, King of *Æthiopia*; and here the good old Monarch stands upon the Globe, with his Scepter in his Hand, just above *Cassiopeia*; and below her, at the very Edge of the Horizon, you see, you are to look for her fair Daughter *Andromeda*, who had the *Andro-* Vanity to think herself handsomer than *meda*. the *Nereides* or Sea-Nymphs, which put them into such a Rage, that they immediately applied to old *Neptune*, the God of the Sea, to revenge the Indignity.

On this, the obsequious Deity sent a huge ugly Monster up into the Country, which did great mischief there: The poor People, who in those days were always
I punished

punished for the Sins of the *Great Ones*, apply'd to the Oracle for Relief, and were told that the only way to appease the Gods, who were all on the Side of the *Nereides*, was, to expose the audacious *Andromeda* to be devoured by a Sea-Monster; which I suppose *Neptune* undertook to get ready for that purpose. This was done, but the

Perseus. gallant *Perseus*, whom you see here on the Globe, just behind her, as her Champion, deliver'd her and kill'd the Monster, and I hope carried off the Lady; and to reward the Mother of so beautiful a Creature, he got *Jupiter* to place her up here among the Stars, and they form the Celestial Chair in which she sits in State: And thus, Madam, I have given you the History of one of the Constellations, and if you please, I can tell you as long and as true a Story of many of the rest.

I THANK you, Sir, said she, but you shall not, this is enough for a Sample; and now I remember all this Stuff about *Perseus* and *Andromeda*, as well as if I had seen the whole Affair, as I believe I did once, or at least good part of it, shewn upon the Stage: And have much oftener seen it in Pictures and Prints. But dropping

ping all Fables, let me go on with my Lesson ; I shall know *Cassiopeia* again, whenever I see her.

BUT, said I, Madam, I have a Story to tell you of *Cassiopeia's* Chair, that is no Fable, but a certain Truth, and yet is equally strange with the other fabulous Relation. About the Year 1572, there appeared a *New Star* in this Constellation, which at first was as big as *Jupiter* appears now to be, and was fix'd to one Place like the rest of the fixed Stars ; but lessen'd by Degrees, and at last, at the End of 18 Months, went quite out, and appear'd no more.

THAT indeed is a very unaccountable thing, said the Lady ; but as I have met with some such Relations of other fix'd Stars, so I shall leave my Surprize, and my Queries about it, till I come to trouble you about the Nature, Uses, and Distances of the fixed Stars in general : for I must have a deal of Talk with you about *that* and other things in Astronomy, before you get quite rid of me, and you must thank your self, if my Curiosity be teasing and impertinent, for you have wound it up to a very great Height I'll assure you. But, pray, Sir, let us now
F go

go on and make an end of our Stars, it grows late and the Air cold.

MADAM, said I, we shall dispatch the rest, as fast as you please, for the way I have shewn you, of finding and distinguishing the Stars above-mentioned, will teach you to do so, by any others in the Heavens: Thus you will see here above the Pole-Star, and about 14 Degrees from him, and a little to the Eastward of the Meridian, the Constellation, called the *Little Bear*, consisting also of seven pretty eminent Stars, of which the lowermost, *now*, or that in the Tip of his Tail, is the *Pole-Star*: You see here, almost due East, a fine bright Star of the first Magnitude, which is called *Lucida Lyra*; and under it, a little to the South of the East, as *Lyra* is to the North, another great Star of the first Light, about 12 Degrees high, which is called *Alcair*: And you can't but take notice of these four Stars here all of the second Magnitude, placed in the Form of a Lozenge, which is called the *Dolphin*. About 8 Degrees high, and about 2 Points and $\frac{1}{2}$ to the Eastward of the South, you see also a famous Star, of the first Light, in the Body of *Scorpio*, one of the 12 Signs.

Ursa Mi-
nor.

Lucida
Lyra.

Alcair.

Dolphin.

Scorpion's
Heart.

ALL these Stars I see, said the Lady, and I think distinguish very well; and I fancy I shall be able, by degrees, by the Help of such eminent Stars as *that*, which I see here on the Globe, are placed pretty near the *Ecliptic*, to *trace out*, as you said a while ago, that Circle in the Heavens. But, pray, first tell me, what you call that Star, or rather Planet, (for I fancy 'tis one of those *wandering* Lights) which appears yonder, almost upon the South Part of the *Meridian*, and about 25 Degrees high.

YOU have guessed very right, Madam, said I, 'tis a Planet, and the most remote one of all, *Saturn*. *Saturn.*

Is that *Saturn*, said she? I'm heartily glad to see him, I shall know him again another time; I long to peep at him thro' a Telescope, and to see his famous *Ring*: But of this, more some other time, when the Telescope, you have promised me, is fitted up. Is there any thing else worth observing, before we remove to our Sleep?

ONLY please, Madam, said I, to take Notice of that *Track of Light*, yonder in
F 2 the

*Milky
Way.*

the Heavens, and here drawn upon the Globe, which is called the *Milky Way*. You see here by the Globe, as the Position of the Heavens is now, that it begins at the North Part of the Horizon, about *Perseus*, takes in *Cassiopeia*, and after that the *Swan*, and then runs on toward *Scorpio*, and towards the *South Pole*, and takes in the famous Constellation called the *Cross*; then it turns *Northward* again, thro' the *Ship*, a little above the *Great Dog-Star*, or *Syrius*, and above the Right-Shoulder of *Orion*, and thence taking in *Capella*, runs on towards *Perseus*, where we began to trace it.

I'm glad you thought to shew me this, said she, before we finish our Night's Observations; I see it plain in the Sky, and perceive that its Figure, on the Globe, corresponds exactly with it: I won't stay now to ask you what it is, because that may be one of my many Questions to you another time; we will only remember what Mr. *Milton* saith of it:

*A broad and ample Road! whose Dust is Gold,
And Pavement Stars, as Stars to us appear,
Seen in the Galaxy, that Milky Way,
Like to a circling Zone powder'd with Stars.*

Mr.

-MR. Milton, Madam, said I, alludes to the Notion that the Poets had of it; that it was the Path which the Gods used in the Heavens, which Mr. Dryden, from Ovid thus also describes:

*A Way there is in Heaven's extended Plain,
Which when the Skies are clear, is seen below,
And Mortals, by the Name of Milky, know:
The Groundwork is of Stars; thro' which the Road,
Lies open to great Jupiter's Abode.*

-SIR, said the Lady, a thousand Thanks to you for the Pains you have taken to instruct me, and I wish you a good Repose.

THE next Day my Affairs called me away, for some time; but at my Return, as I found the Telescopes and other Instruments, I had sent for, in perfect good Order, so I found the Lady had been close at her Astronomical Studies: She was exactly ready in all Problems upon either Globe, and had gotten such an intimate Knowledge of the Stars, that she had also acquired a very tolerable Knowledge in the several *Systems* of the Universe, or *Hypotheses* to solve the Celestial Appearances, as they are called by Astronomers; and long'd with great Impatience to see the

Use of the *Telescopes* and *Quadrant* &c. which I had sent down to her Country-Seat.

Where soon after I arrived, she put me upon beginning our Observations, and had methodized the Enquiries and Questions she designed to make, with great Address and Dexterity.

Sun. LET us begin, said she, to talk a little about the *Sun*: I think you agree, that his Center appears to move always in the same Line, or in the *Ecliptic*; but I think you say his apparent Motion is *unequal* there.

'TIS true, said I, Madam, for when the Earth is *nearest* the Sun, as she is in Winter, then she, in *reality*, and the Sun, *seemingly*, moves *faster* than in the Summer, when the Distance between the Earth and the Sun is greater; and accordingly the Sun's Diameter appears *bigger* in Winter than in Summer.

BUT, Sir, 'tis strange, methinks, said she, that the Sun's *nearer Approach* to us in Winter than in Summer, doth not counterchange those Seasons: Have not we the greatest Heat from the Sun when we are nearest to him?

No,

NO, Madam, said I, for the different Heat of our Seasons of the Year, do not depend upon *that*, but upon the Sun's Rays falling more *directly*, or more *obliquely* upon us; together with the length of his stay above the Horizon, which is a great deal longer every Day in Summer than in Winter: For in the Distance of 20,000,000 of Miles, a little Approach of the Earth to, or its Recess from the Sun, will make no sensible Alteration as to Heat or Cold. But there is another thing arising from this Inequality in the Earth's Motion round the Sun, which is pretty considerable, and that is, that the Sun will appear to tarry about 8 Days longer in the Northern Part of the Ecliptic than he doth in the Southern; the Reason of which is, from the Figure of the Earth's oval or elliptic Orbit: [See Lexic. Techn. Vol. II. under Sun.] And thus having given you some general Ideas of these things, I wait your further Commands.

WHY, then, said the Lady, pray give me now, for it seems to be a proper Place, some little Knowledge about the *Equation of Time*, which I have read a good deal about, and Tables of which I have seen hanging by Clocks, and put upon Dials

F 4

and

and Watches; pray, can our Sun be in the wrong, don't he measure Time equally?

MADAM, said I, the daily Revolutions of the *Earth's* Equator round its Axis, are exactly equal in Time to one another; and yet the Time from the apparent Noon of one Day to that of the next, is unequal, and sometimes greater and sometimes lesser.

WELL, said she, I'm glad however, 'tis not our Earth's Fault, and that she is so regular in her diurnal Whirls: But, pray, let me then know, where the Error, or Inequality, lies?

THERE is, said I, Madam, a double Cause of this Inequality; the former is, that the Earth's Annual Orbit is not an *Exact Circle*; and the other is, that the Earth's *Equator*, about which the Diurnal Motion is made, and the *Ecliptic*, or the Circle she describes round the Sun, are not *co-incident*, or in one and the *same Plane*, but make an Angle, as you know they do, at their Intersection, of $23^{\circ} 30'$ of which when your Curiosity, and further Knowledge of these Affairs, leads you to make more full Enquiries, you will

will receive a plain and satisfactory Account, from Mr. *Whiston's* Astronomy, p. 116, 117, &c.

I thank you, Sir, said she, but, pray, let us now get all things ready to look on the Sun, with your Glasses, that I may know, by my Eyes, as much as I can of that wonderful Luminary, the great Center of all the Planets Motions.

OUR Telescope was about 14 Foot long, and had a plain Glass smoaked with a Candle, screw'd on before the Eyc-Glass, to defend the Eye from receiving any Injury from the too intense Light of the Sun.

AFTER she had look'd upon him 2 or 3 times ; It appears plainly, said she, to be a great Globe of Fire, or rather, as *Butler* saith,

*A Piece
Of red-hot Iron, as big as Greece.*

and so no doubt it must be, by the great and constant Heat which it gives: But, pray, tell me, as fully as you can, what the late Astronomers and Philosophers have

have discover'd about this vast World of Light. I perceive you suppose him fix'd and immoveable, as to Place, in the Center of what you call the *Solar System*; but doth he turn round his own Axis or not? how much bigger is he than our Earth? how far is he from us? and how can his Heat continue so long as it hath done, without any sensible Waste or Diminution?

*Solar
Spots.*

MADAM, said I, by observing carefully the Spots, which often appear in the Sun's Face, tho' there happen to be none now, they have discovered, that the Sun revolves round its own Axis, in about 25 Days.

SPOTS! said she, What, are there *Spots* in the Sun, which sometimes appear there, and sometimes not; for God's sake what are those *Spots*?

THERE are various Opinions about them, Madam, said I; but the most probable one, is, that they are a kind of Dross or Scum which sometimes gathers upon his Face, as is the Case of melted Metals; for I have seen several *Spots*, which for a time appeared distinct, at last some of them quite vanish'd, and others

others run together into one, and so composed a much greater Spot, as was the Case at the Time of the last famous Eclipse of the Sun; and some of these Spots must be immensely large, to appear so big as they do, sometimes, to us, considering the prodigious Distance of the Sun, *Distance* which probably amounts to about 70 or 80 *of the* Millions of Miles. *Sun.*

EIGHTY Millions of Miles! said she, Why you fright me, my Head turns round, and I'm giddy with the very Notion of it!

AND yet, Madam, said I, as great as this Distance is, a Ray of Light runs it in about 7 or 8 Minutes Time; while such a swift Traveller, as a Cannon-Ball, supposing it to move all the way as fast as when it just parts from the Gun, can't arrive there in 25 Years. These things must needs appear wonderful and surprising to you, but we have *very good Reasons* to conclude, that they are very near to Truth; *which* I forbear to mention, because perhaps at present, you may not be qualified fully to comprehend them.

I doubt indeed, I am not, said she, which I heartily lament, and I envy you Men and Scholars, as much as I dare, the Pleasure of knowing the Reasons of, and inquiring into the Natures of these amazing things. But, pray, Sir, is not the Bigness of the Sun answerable to this vast Distance that he is from us?

YES, Madam, said I, according to these Ways of Computation, the Sun's Diameter, or his Breadth from one Side to the other, is about 800,000 Miles, which is above 100,000 times greater than the Diameter of our Earth; and therefore his Bulk, or rather the Quantity of Matter in the Sun, must exceed that of the Earth above 10,000,000 times.

And this Consideration of the Vastness of the Sun's Magnitude will account for the Query you rightly enough started, how he can so long continue his Heat without any sensible Diminution? For we take the Sun and the fixed Stars to be only very great Bodies of Earth, vehemently hot, whose Heat is preserved by their Greatness, and by the mutual Action and Re-action between them and the

Sir Isaac
Newton's
Opticks,
p. 318. last
Edition.

the Light which they emit, and whose Parts are kept from burning out and fuming away, not only by their being of a fixed Nature; but also by the Weight and Thickness of the *Atmospheres* which are round about them, and which do strongly compress them, and condense the Vapours and Exhalations which would otherwise fly away from them; but are now by this Means made to fall back again upon his Body. And as to the daily Expence of his Light and Heat, the Particles of Light are so infinitely small, that out of a Body so big as the Sun, they may be sent for many hundred thousands of Years together, without any sensible lessening of his Bulk, Weight, or Magnitude.

I believe, I comprehend the main of your Reasoning, said she, but I am got a little out of my Depth; let me recover firm Ground again, and then I would ask you farther, whether, since you take the Sun to be an immense Globe of Earth, thus set on fire, and the fixed Stars to be Suns, or Bodies of the same Nature, you don't think the Stars, severally, to have the same Use, and to be the *Centers* each of them, of *Systems of Planets* revolving round them, as ours do

Fixed Stars so many Suns.

I round

round the Sun, to whom they afford such all-cheering Light, and enlivening Heat, as our Sun doth to us? For methinks 'tis a mean Use of them, and below the Wisdom of our *Great Creator*, to place them in the Sky only to twinkle and divert us; whereas, all of them put together, don't afford us the 10th Part of the Light of the Moon; but if we suppose them all to be Suns to some *other Systems* of Planets, because of their vast Magnitudes, and because of their shining, as I think you agree they do, by their own Light, and not with one borrowed, like that of the Planets; what a glorious Idea doth it give us of the Almighty Power! of the Wisdom and Goodness of the Divine Nature? And what a poor contemptible Opinion ought it to make us entertain of our selves, who perhaps may bear as little a Proportion in *Wisdom* and *Knowledge*, to some of the Beings that inhabit the Starry Regions, as we do in *Magnitude* to them all; for I can easily conceive infinite Degrees of Knowledge and Perfection, with as great a Variety, that may be in a *Series* in Creatures between us and the Deity; and perhaps there may be also a considerable one below us.

I AGREE intirely with you in that Speculation, Madam, said I, but we must touch it tenderly, or else the old Divines will be angry.

A Y, said she, such of them as imagine all things made for the sake of *Man* only; but I have no such lofty Notions of the Dignity of our Species: and I think Mr. *Oldham's* is a very just Satyr upon that narrow Notion, when, with regard to the very Point before us, he saith, that Man believes,

That turn-spit Angels tread the Spheres for him.

But now I'm talking about the Stars, pray tell me once for all, have these Stars and the Planets no real Influence upon us Mortals?

NO T at all, Madam, said I, so as by any Physical Power to influence our Wills, Lives, and Actions; that kind of Effect is certainly more true with regard to what the Stars have often been *unequally compared*, the *Eyes* of a fine Lady of good Sense and Virtue; for *Those* do certainly, like the *Eyes of a good Magistrate*, scatter and disperse all Evil before

fore them: They heighten our Genius, and inspire us with Wit, and yet keep our Conversation as chaste and modest as they make it entertaining and instructive.

I ALWAYS take your Compliments for *Instructions*, said she, and have no Excuse to make for the Vanity of being pleased with them, but that I will endeavour to be as good as you represent us, and we shall have a much better Reason than ever to value the Power we may have over your Sex, if we can make it help us to reform it: But you will not allow me then to believe any Astrologic Influences?

NOT any at all, said I, Madam, for they serve only to nurse Superstition, to fill us with false Fears, deceive us with vain Hopes, and to excite a dangerous Curiosity, and an unreasonable Inquisitiveness into Futurities; and it is indeed, in effect, either making the Stars so many Deities, and consequently running into some of the worst Sorts of the Idolatry of the Heathens; or else 'tis introducing the Notions of a Physical Fatality, and banishing out of our Minds all Religious and Moral Notions.

SIR,

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*This Sun, of our poor World both Eye and Soul :
This Sun, that with surpassing Glory crown'd,
Looks from his sole Dominion like a God ;
That by magnetick Beams thus gently warms
The Universe, and to each inward Part,
With gentle Penetration, tho' unseen,
Shoots genial Virtue even to the Deep :*

'Tis very justly observed, Madam,
did I; for indeed, whatever their Bigness
(and much less than the Sun we have
no reason to suppose any one of them to
be) their *Distance* is so great, that the *Their*
Diameter of the Earth's yearly Orbit or *immense*
circle round the Sun, which you know *Distance*.
must be double to his Distance from us,
and therefore about 160 Millions of
Miles: This I say, according to all the
G Observ-

Observations we can make, and the Reasonings we can form, bears no manner of Proportion, and is but a Point, in comparison of the Distance of the *nearest fixed Star*; for we have no reason to suppose them *all equally remote* from us. And could we advance towards these Stars 99 Parts in 100 of the whole Distance, and that there were but one hundredth Part of the present Distance remaining, they would appear very little larger to us than they do now. The Distance of *Sirius* or the *Dog-Star*, Mr. *Huygens* takes to be about 27000 times as far from us as the Sun is; so that I believe we are not much out of our Computation, when we conclude, that a Ray of Light cannot come from thence in less than 6 Months time, nor the Cannon-Ball, above-mentioned, in 50000 Years.

GOOD God! cry'd she, how immense and wonderful are the Works of thy Hands! Why then, said she, if all the Stars were to be extinct or annihilated this next Night, we should not miss them till about 6 Months after!

No, Madam, said I; that Stream of Light now flowing from them to our Eyes, should the Fountain be stopped, would

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would be half a Year before it would be run quite out; tho' it run after the rate of above 10 Millions of Miles in a Minute; Motion almost as quick as Thought itself, as we usually say.

WELL, said she, this hath made an extravagant Notion of Mr. *Whiston's* about the Distance of *Heaven*, or the Region appointed for the Bodies of the Blessed, is not being by any means so far off as the supposed *Empirean Heaven* of the Divines, much easier to me than it at first appeared; and which then I thought a very new, wild, and unaccountable Opinion. But, pray, let's go on; Is not the Number of these fix'd Stars as wonderful as their *Distance*?

Vid. Accomp. of S.S. Prophecies, p. 288.

YES, in truth is it, Madam, said I; for as the naked Eye discovers immense Numbers of them in a clear Night, (above 1000 of which are distinguished and taken notice of) and many more in the Northern cold Countries than we can do here; so when assisted by a Telescope of any great Length, it sees amazing Crouds of other Stars, which because they are invisible without these Helps, the Astronomers have called very properly *Telescopical Stars*. Such a Glass as this which

Telescopical Stars.

*Milky
Way.*

we but now used to observe the Sun with, will discover to you many Thousands of Stars, before invisible to the naked Eye; and I think I have told above 70 within that little *Bunch of Stars*, which we call the *Pleiades*, or the 7 Stars; tho' now there appear but 6 to the bare Eye. The *Milky Way* is crouded with infinite Numbers of small Stars, from whence, as is usually thought, its *Whiteness* appears; which is a Discovery entirely owing to the Telescope; but whether the Whiteness proceeds from the *Smallness* of those numberless Stars, their *Nearness* to one another, or their *immense Distances*, we can't yet certainly determine, but must leave to Time and future Observations.

How endless is the Extent of the Divine Power and Goodness, said she, and how far are we yet from knowing the Bounds of the Starry World! But, Sir, your hinting, that formerly there were seven where now there appear but six Stars in the *Pleiades*, reminds me of your Promise, to acquaint me with the History of some Appearances of *New Stars*, and Disappearance of others, in *Cassiopeia's Chair*, and in some other Places in the Heavens.

MADAM,

MADAM, said I, the *Milky Way*, in which *Cassiopeia* is placed, hath been famous for these Appearances; many new Stars having been discovered in the *Swan*, *Andromeda*, the *Ship*, *Eridanus*, and other Constellations within that Tract: Some of which have, after some time disappeared, and then re-appeared again. Of these things you may see several Instances collected by the Author of *Lexicon Technicum* (a Book which your Ladyship hath) under the Title of *Fixed Stars*, in the second Volume. But 'tis difficult to determine, what these new Stars are; some fancy them to be Planets revolving round some of the Stars in the *Galaxy*, and which therefore become visible only in that Part of their Circle which is next to us; others take them to be Comets, and others think that they are really *fixed Stars*, whose Light and Vapours expire, but are again recruited and enkindled by the Access of Comets towards them: But these *Hypotheses* can't well solve all the Phænomena; for besides the Appearances of these *New Stars*, it hath been observed of the known fixed Stars themselves, that some of them have much changed their Magnitude and their Light; some of them have quite

Ricciol.
Almagest
Hevelij.
Prodrom.
Mercator
Astron. in
Append.
Philosoph
Transf.
Miscellanea
Berlin.
Whiston's
Astron.
Derham,
&c.

disappeared for a Time, and then come into sight again ; and this at certain Times and determined Intervals. And when you come to read what Mr. *Huygens* observed of the Stars in *Orion's Sword*, you will meet with what will very much, and I believe very agreeably, surprize you ; but let it be which way it will, 'tis a wonderful *Phænomenon*, and perhaps will never be thoroughly known, if ever, till future Ages have increased our Observations, and improved our Reasonings upon them.

I THINK, said the Lady, I have enough for this time, about the Sun and the fixed Stars ; I will consider of it, and have recourse to the Books you recommend to me, and trouble you the next time about the Planets, in the Order as they are in, with respect to the Sun ; only give me leave to break in upon it, with regard to our own Planet, the *Earth*, and her Attendant, the *Moon*. With which, out of Self-love, or rather Inclination to the Place of our Birth and Abode, I would fain begin, if you don't judge it to be improper.

By no means, Madam, said I ; for many things will occur in our Discourses about the Moon and Earth, which are very common

mon and obvious Appearances, and which thoroughly accounted for, and explain'd, will render the Knowledge of the other Planets much more easy, and intelligible.

N O T long after this, the curious Lady attack'd me again, thus: I have been considering, said she, the amazing Subject we discoursed upon the last time, and am prepared now to talk with you about the *Earth* and the *Moon*, and the different Magnitudes, and Motions of each; and of this I find it previously necessary to have some Knowledge, or else my Enquiries into *those* of the other Planets, will not give me sufficient Satisfaction: Pray, Sir, how many Miles is the Diameter of our Earth reputed to be, by the Astronomers?

S O M E T H I N G less than 8000, Madam, said I; and because I know you will expect it, I must tell you, that we attain this Discovery thus: Both in *England* and in *France*, a Measure in Length hath been taken upon the Earth's Surface, under one and the same Meridian, or, in a right Line running exactly North and South, till by accurate Instruments it was found, that the *Pole* was *raised* or *depressed* exactly one Degree. This, the Mathematicians of both Nations agreed in to be

almost 70 Miles, *English*: And there being 360 Degrees in every Meridian, that Number, multiplied by the former, gives you the Number of Miles in the whole Circumference of a great Circle on the Earth, or how many Miles it is round our Globe; and then, by the Principles of Geometry, they know, that something more than one Third of that must be the Earth's Diameter. I don't trouble you, Madam, with the exact Numbers, nor the Multiplication and Division, but you may depend upon it, that the round Number of 8000 Miles, is pretty nearly the Earth's Diameter, tho' something too much: And the half of *Earth's* this, *viz.* 4000 Miles, is the *Semidiameter*, *Semidia-* or the Distance from the Surface to the *meter.* Earth's Centre, a Number, or Measure, much used by Astronomers.

I THANK you, Sir, quoth she, for this; the Knowledge of this single Point, will, I see, carry me a great way, when I come to read Astronomical Authors: But, pray, Sir, go on and oblige me with a further Account of this Earth: Do you think it really turns round its *Axis*, as you have found the Sun to do by its *Spots*?

YES, Madam, said I, and as there is nothing more easy and simple than this Motion,

Motion, so it accounts for the Appearances of Day and Night in an easy and natural manner; for as this Earth revolves from West to East in exactly 24 Hours Time, it makes the Sun *appear* to do so from East to West in the same time; and makes it *Day* to those Places on its Surface, which are turned towards the Sun, and *Night* to such as are in the opposite Parts; as you see, Madam, if I set this Globe into the Sun's Light, it will illuminate *but one Half* of it, and the *other Half* will lie in the Shadow; but as I turn the Globe round its Axis, all Parts of the Earth's Surface painted upon it, will come successively into the *Light*, as the opposite Parts go, after the same manner, into the *Dark*.

I GRANT you, Sir, said she, this is a very natural and easy way of accounting for the Vicissitudes of Day and Night; and so short and unembarrassed in comparison of the other wild Notion, which makes the Sun, and all the Region of the fixed Stars, to revolve round us in 24 Hours, that it recommends itself to us, at first sight, as agreeable to the other Proceedings of Nature, if we could but get rid of our Prejudices, so as to conceive it possible to be done, without our perceiving

ceiving it. But can we travel above 1000 Miles in an Hour, and not be sensible of it?

As easily as to in a Ship, Madam, said I; where, let the Vessel move never so fast forwards, if it were not for the Tossings and Shocks which the Resistance of the Water and Waves make, and for the Rustling and Bustle that the Wind makes in the Sails, you would perceive no Motion at all in the Ship, but judge it to be perfectly at Rest; and if another Ship lay at Anchor by you, you would judge that to move *backwards*, and not your self *forwards*. And much more will this appear plain, if you consider that with the Earth's Motion round its Axis, the Air, and all the Atmosphere moves along with you, and doth not resist you, as is the Case in the Motion of a Ship. But indeed, the greatest Wonder in this Case is, that we are not all whirl'd off into the Air, like Dirt from a Wheel, or Drops of Water from a twirling Mop, or Stones parting from a Sling.

YOUR talking of the *Twirl of a Mop*, said she, puts me in mind of a whimsical Description of *that Action*, which a Friend of yours made to ridicule some

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Verbose Verses then repeated: But tho' I have almost forgot them, I hope you have not.

MADAM, said I, your Ladyship's thinking of them now is proper enough; for tho' made to *expose* another Matter, they will *illustrate* what we are upon:

*See how Culina with hard adverse Wrists,
The dreary Radii of her Mop untwists;
Swift twirling round, the oblong Planet rolls,
With Axe produc'd thro' the Meridian Poles;
The Stiff'ning Threads their rigid Form preserve,
While dirty Drops fly off in Tangents to the Curve.*

WHY this is very true, said she, of those dirty Drops, and I can't imagine why 'tis not so with us; for I don't know any thing that fastens us down to the Earth, but our firm Inclinations to this World, which I believe *Centripe-* yet hath no Physical Power to keep our *tal Force*. Bodies annexed to its Surface. Pray, how do you account for this Difficulty?

BY that Will of the Creator, Madam, which we call the *Law of Gravity*, or *Gravitation*; whereby all heavy Bodies have a Tendency towards the Center of our Earth, in such an Over-Proportion, that the *Centripetal Force*, by which Bodies
tend

tend thither, is almost 300 times greater, than that by which they are forced off by the Earth's Motion round its *Axis*, or the *Centrifugal Force*, as they call it; and 'tis this *All-wise Provision* that keeps all things together on the Surface of the Earth; and which, when exactly adjusted, keeps also every Planet in its proper Circle, and at its due Distance from the Sun, or from its Primary one: And this is so universal a Law, that it prevails every where. And if a Cannon-Ball could be discharged from any considerable Height, in the Air, parallel to our Horizon, and with a Velocity equal to that of the Earth's Attraction, or the Force of Gravity towards the Earth's Center, it would then neither *fall* to the Earth at all, nor go quite *off* from it, but would *revolve round* it, like our Moon; and this is the very Reason why she doth so.

WELL, said she, a new World of Knowledge opens and dawns upon me! I begin to see a thousand Things, of which I had no Notion before; and I believe the Motions of the heavenly Bodies, after this, won't appear such abstruse unintelligible Things as I imagined them to be: But, pray, Sir, explain this a little further, with regard to the Moon.

YOU

Y O U must know, Madam, said I, that this Gravitation of a Planet towards any Central Body, decreases as the Square of the Distance from that Center increases ; therefore the Moon being about 60 of the *Moon's* Earth's *Semidiameters*, or 240000 Miles *Distance*. distant from us ; her Gravitation towards the Earth, will be 3600 times less than that of a Cannon-Ball shot out of a Gun on or near the Surface of our Globe ; for the Moon's distance from the Earth, 60 of the *Earth's Semidiameters* being *squared*, that is, multiplied by itself, makes 3600 ; and if she were but 2 Semidiameters removed from the Earth, the Square of 2 is 4, and as much as 3600 exceeds 4, so much does the Attraction of the Earth, or any Central Body exceed at 2 Semidiameters above that of its Attraction at 60 Semidiameters. And the Great Creator hath so wonderfully contrived it, that her *Centrifugal* Force, or her Endeavour to fly off from the Earth, is exactly equal to her Gravitation thither ; and this keeps her in her Orbit, as it doth all the Planets in theirs, as I said before.

O wonderful and happy Adjustment !
said she ; for I perceive, if the Moon's Gravity towards the Earth were much
I abated,

abated, she would run out of her Orbit, and leave us; and if the opposite Force were much lessen'd, she would in a little time, tumble down upon us: Am I right, Sir, in this Conclusion?

EXACTLY, Madam, said I, and I perceive I need not say much more to you upon this Head, except it be to tell you, that if the Centrifugal Force were taken away from the Planets, and that only the Power of Gravitation towards the Sun remain'd, they would all soon fall down to him, and our Earth would get down thither in about 64 Days and 10 Hours time.

But I think, Madam, we are gotten to the Moon a little too soon, having not yet quite done with the Earth, whose Annual Motion round the Sun therefore, let us next consider: By which all Increase and Decrease of Day and Night, and the *Changes* and *Seasons* of the Year are made.

AND can you give me any good Reasons, that I can understand, to believe this Annual Motion of the Earth, said she?

I think, Madam, said I, there is in Astronomy a *plain Demonstration* for the Motion of the Earth round the Sun; but it will be too remote for your present Knowledge of these

these Matters: However, I think 'tis a very good *Argument* for its being so, that *this way* there is a Parity and Agreement with the other Proceedings of Nature, which is very suitable to the Wisdom, Easiness, and Conciseness observed by the Divine Being: For it being now agreed, that the Sun is the Center of all the other Primary Planets, and that we are placed in such a due Distance from the Sun, between the Orbits of *Venus* and *Mars*, as answers to the Time of those Planets Revolution round the Sun; and since 'tis also agreed, that the other primary Planets, as well as *Mars*, *Venus*, and *Mercury*, do, in their several Orbits, revolve round the Sun; what Reason can possibly be assigned, why the *Earth* should not do so too? since *they* are *Earths* likewise, as our *Planet* and the *Moon* are, and consequently our Earth must be as capable of moving round the Sun, or any other Center, as *they* or *she* are.

I own, said she, that tis much more natural, orderly, and harmonious to suppose it so; and therefore I will lay aside all Prejudice, and believe it with a good Astronomical Faith.

MADAM, said I, if you will observe what *Fontenelle* saith, very justly, of Nature,

ture, that *She is always magnificent in the Design, but frugal in the Execution of it*, you will never believe that the Sun and fixed Stars turn all round us in 24 Hours; when you reflect, that the bare Motion of the Earth round its Axis will answer all your Ends that are to be served by the other. That would be just as absurd, as for a great Architect to contrive, with vast Expence and Machinery, a *Kitchen-Grate*, that should revolve round a Spit, in order to roast a *Wheatear*, or a *Wren*; but never so much as dream of a way to turn the Spit round.

'Tis monstrous, said she, as well as ridiculous, and, as I told you before, I won't believe one word about it: I see, that the more *plain* and intelligible things are, the more they are valuable; and that *Obscurity* and *Mystery* are usually the Effects of Ignorance, and want of Skill either in the Operator, or the Explainer. But, Sir, will you give me leave then to step to the Moon, and ask you a few Questions about her, for I can't put those fine Lines of *Butler* out of my Head:

Moon.

*The Moon put off her Veil of Light,
Which hides her Face by Day from Sight;
Myfte-*

*Mysterious Veil of Brightness made,
That's both her Lustre, and her Shade ;
And then indeed as freely shone,
As if her Rays had been her own :
For Darkness is the proper Sphere,
For borrow'd Glories to appear.*

And I know a good deal of his Meaning in them ; as *that the Moon borrows her Light from the Sun*, &c. but I could be glad if you would explain a little upon that Matter, and upon her Motion round the Earth ; after we have at Night examined her Face by the Telescope : Is this a good Time to look at her ?

YES, Madam, said I, a very lucky one, for she is now increasing, and not quite full ; we shall see her *Mountains* more distinctly, and the Light of the Sun move from one Hill to another.

THE Evening, according to our Wishes, proved very clear and fair, and the Lady was mightily pleased with the *Face* and Appearance of the Moon thro' the Glass ; and having also the Day before been reading a little in Mr. *Huygens's Cosmotheoros*, or his Celestial Worlds discover'd, or Conjectures about Worlds in the Planets ; and in Mr. *Whiston's* late Book, called *Astronomical*

mical Principles of Religion; she was prepared to ask me some very proper Questions, and began thus :

PRAY, Sir, said she, is not our Earth a *Moon* to the Lunar People, as well as she is to ours ?

YES, Madam, said I, and a most useful and a glorious one too; and we may, in some measure, perceive *that* our selves, by the Light which our Earth reflects upon the Moon before she is just *new*, and for some time after; for doubtless *that* is the *only* Light that then renders her visible to us: And when you consider that the Light of our Earth, consider'd as a *Moon*, will be thirteen times greater than that of the *Lunar Light* to us, it won't appear strange, that its Reflection on the Moon should render her *then* dark Body visible to us. However, this Terrestrial Light, when the Earth appears at Full to the People in the Moon, is not above a 3600th Part of the Sun's Light there, as the Light of our Full-moon to that of the Sun, shining upon us, is about as 1 to 48000.

I THANK you for this, Sir, said she, and am heartily glad *we* can be so useful to the *Lunar World*. But, pray, go on:
I

perceive, said she, you agree that the Moon as well as all the rest of the Planets, turns round her own Axis, which, methinks, in her is very strange; for we seem to discern always the same Face of her, without any Variation: Pray in what time is that Motion perform'd?

JUST in the time, Madam, said I, that she is revolving round the Earth; which I will explain to you presently: But, first, it will be proper to inform you, that the figure of the Moon not being exactly globular or spherical, but a little oval, or like that of an Egg, her longest Diameter (which exceeds her shortest by about 200 Foot) would, if you suppose it extended so far, pass thro' the Centre of our Earth: And hence it is that we see always the same Face of the Moon obverted towards us; and that *this* is not hinder'd by her Motion round her Axis, this familiar Instance will shew you. Please to sit still, without turning your self, while I walk round you; you will then see plainly, that if I keep my Face always towards one and the same point of the Compass, while I am moving round you, when I come a Quarter of my Circle, my Right-side, and not my Face, will be towards you; when I have gone half way round you, my Back; and when

I'm gotten three Quarters, my Left-side will be turned towards you; but if, as I move in my *proper Orbit* round you, I always keep turning towards you, as indeed I can't help doing, you will then always observe me beholding you with the same Face of Respect and Esteem.

Y O U Men, said she, are not like those constant Celestial Lovers; for you seldom continue your Respect for above a Revolution or two: However, you may now stop in your *Circular March*, continued she, for I see the thing plain, and that the Reason why we see always the same Face of the Moon, is because she moves round her *Axis* in the same time that she performs her Circle round the Earth: But pray, let me know something more of the manner of her Motions.

M A D A M, said I, the Moon revolves continually from West to East, and that pretty nearly in the same Circle which we call the Ecliptic; but not exactly, sometimes running 5 or 6 Degrees above it to the North, and sometimes below to the Southward: She doth not also keep always the same Distance from the Earth as appears by her Diameter, which when we come to measure, we find sometimes

considerably larger than at others; she moves swifter in the *Syzygies*, as they call them, that is in their *Conjunctions* with, and *Oppositions* to the Sun, than she doth at her *Quadratures*, or when she shews just half of her Face.

WELL, said she, I perceive now that her Motion is so irregular, that some Comparisons, which have been made with her, are not quite groundless: But this Part I fancy I shall get over by my Books, and I think I know also, that the Reason why she appears *full*, is, because she is then *opposite* to the Sun, who shines *full* upon her; and we lose Sight of her in what we call the *New Moon*, because she is then between us and the Sun, or in *Conjunction* with him; and 'tis easy to see also that all her other *Changes* and *Appearances*, or *Phases*, as I remember you call them, are accountable from her being in some *intermediate Position* between *new* and *full*. But, pray Sir, why have not we an Eclipse of the Sun at every *new Moon*, and one of the Moon at every *full*?

THAT is owing, Madam, said I, to the Moon's Latitude, by which she runs sometimes 5 or 6 Degrees from the *Ecliptic*, (in which the Earth always moves) both

Northward and Southward. But if her Orbit, and that of the Ecliptic, were all in one Plane, there would be total and central Eclipses at every *new* and *full* Moon.

I CONCEIVE what you say, said she; so that there can be no *Eclipse* of either Sun or Moon, unless the Moon be in the Ecliptic as well as the Earth, because the Sun's Light will go *by* or *besides* the Earth or Moon.

YOU have it exactly right, said I, Madam, in general; all that I need tell you further is, that if the Moon have but a *very little* Latitude, an Eclipse may happen, or if she be at the time of the *Conjunction* with, or *Opposition* to the Earth, in or near the *Nodes*, as they call it, that is the Points where the Moon's *present* monthly Circle crosses the Ecliptic. And this falling out commonly twice in every *Synodical* Month, or *Lunation*, as we call it, there would be an Eclipse of the Sun every *new* Moon, and an Eclipse of the Moon every *full*, if the Earth could stay about the *Nodes*, and did not proceed on in her Orbit all this while, or change her Place in the Ecliptic forward on. However, within the Compass of the Year there

there happen usually four notable and almost total Eclipses, somewhere or other, two of the Sun and two of the Moon. But your Ladyship will please to consider, that there is in the Nature of the thing a great deal of Difference between these two kind of Eclipses: For in the *Lunar Eclipse* there is a *real Loss* of the Moon's Light; for the Moon being immersed in the Earth's Shadow, receives none of the Rays of the Sun, and therefore can reflect none of them to the Earth: and it is also over the whole Earth the same, from whencesoever it is seen, not being changed by the diverse Position of the Spectator on any Part of the Earth's Surface, whether he be in the Equator, or at the Poles.

But in an *Eclipse of the Sun*, there being no real Loss of the Sun's Light, but only an Interception of part of it, from coming to our Eyes, by the Interposition of the Moon's Body; this Eclipse must appear different according to the different Places on the Earth, from which a Spectator may observe it: for tho' to that Part of the Earth to which the Centre of the Moon is then interposed between the Observer's Eye, and the Sun's Centre, it will be *total*, yet it will be but a *partial* one to all other Places, and none at all

Fig. III.

to the remote ones, as you will easily see by *Plate III.*

I THANK you for explaining the *Nodes* to me, said she, and these Phænomena of Eclipses; and by it you have now saved your self the Trouble of answering many Questions: And I perceive, for the future, I shall get to understand these kind of Things and their Terms of Art, pretty well: My *Lexicon Technicum* is a ready Help to me in time of need, and I believe the Doctor compos'd it out of a peculiar Regard to our Sex; I'm sure we are very much oblig'd to him for it. But have we any thing further to say about this *Vagrant*, the Moon, of whom *Dryden* speaks a little coarsely, methinks, in his Translation of *Ovid*:

*Nor equal Light the unequal Moon adorns,
Or in her waxing, or her waneing Horns;
For every Day she wanes, her Face is less,
But gathering into Globe, she fattens at Increase.*

MADAM, said I, happy is your Taste in every thing! A piercing Judgment, great Memory, sedate Consideration, and fine Luxuriances of Wit, seldom unite in one Person; but you are adorn'd with all.

PRAY,

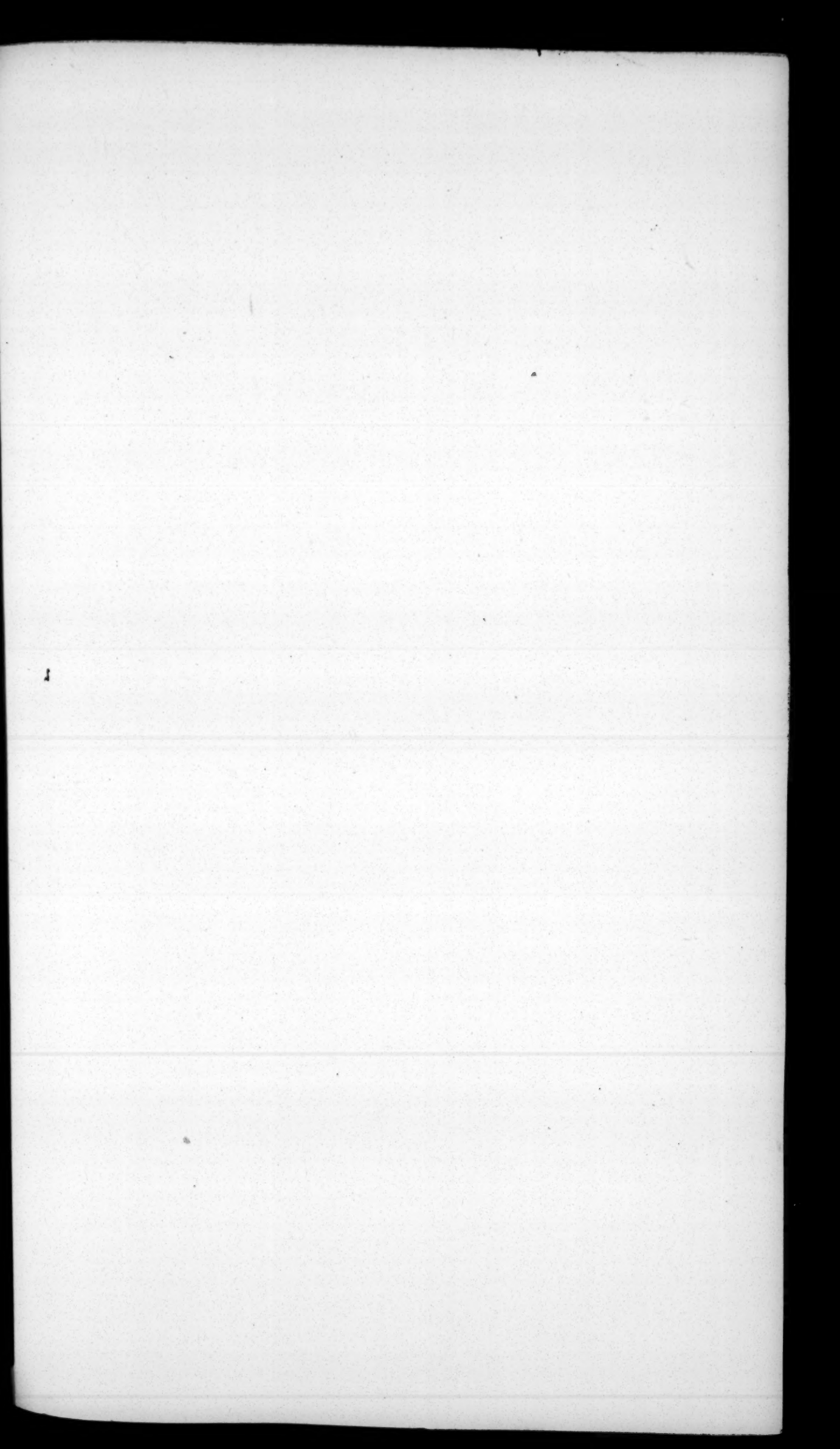
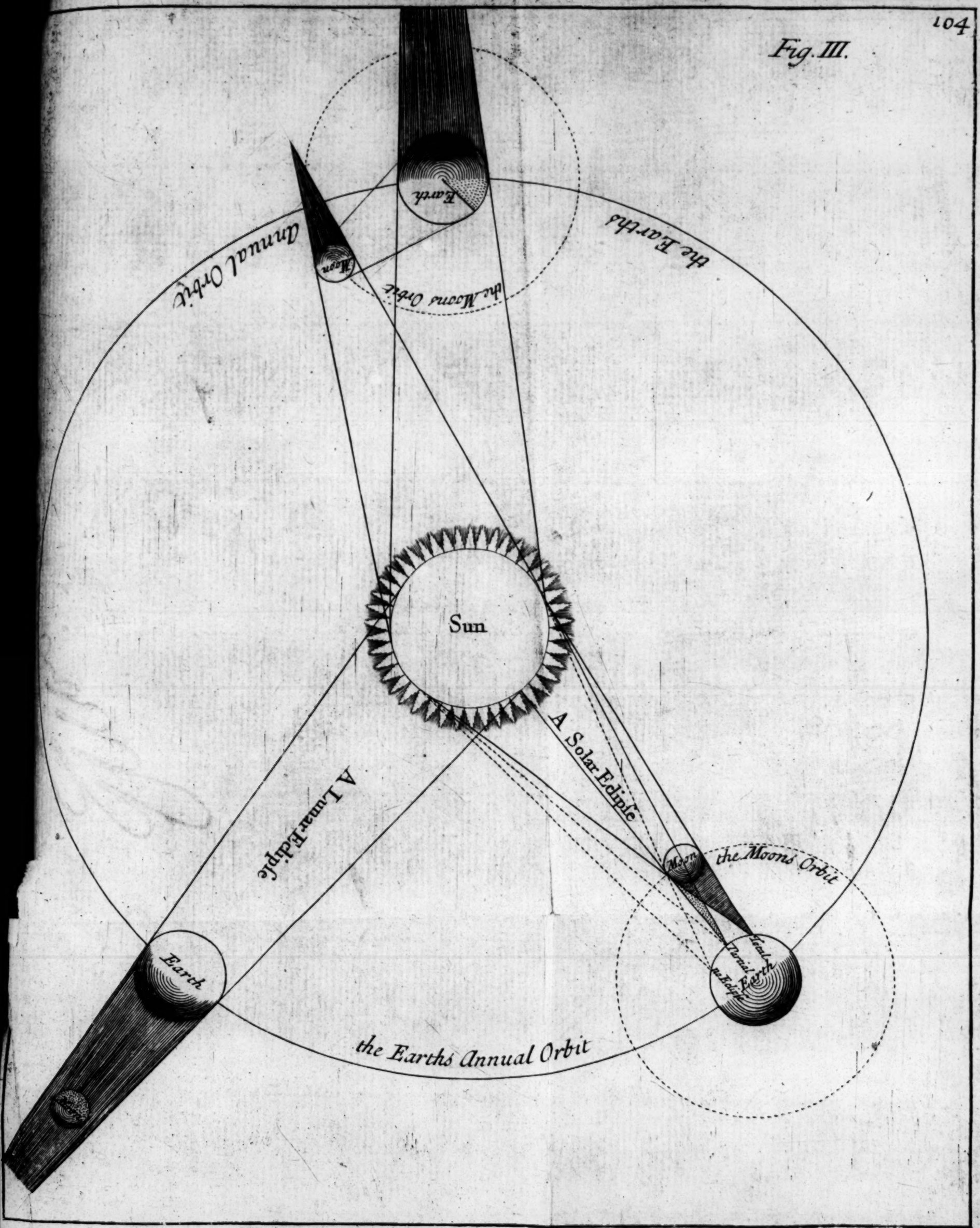


Fig. III.



PRAY, Sir, said she, cease your high Strains, or else I shall begin to think, as *Hudibras* expresses it, That

*The Queen of Night, whose vast Command
Rules all the Sea, and half the Land;
And over moist and crazy Brains,
In high Spring-Tides at Midnight reigns,*

had last Night some Effect on my *Teacher's* Head.

MADAM, said I, between you both, I own I am now and then a little flutter'd. — But your last Verses mentioning the *Tides*, put me in mind of another great Influence and Use the Moon hath over this Earth, besides the great Light she gives us; and that is, that she is the principal Cause of our *Tides*, which are so beneficial to us, in keeping our Ocean sweet by their Motion; and in helping the Navigation of our Ships in Rivers, and Places of the Sea, near the Shores. But I will refer you to the *Lexicon Technicum*, under the Word *Tides*, for an Account of it, where you may receive full satisfaction, with regard to this Affair; formerly so very unaccountable, but now very clear and intelligible.

I CAN'T leave, said she, this inconstant Planet, whom your ill-natur'd Wits have so often made the Resemblance of our Sex, without asking you a Question or two more; What is that you call the *Hunter's Moon*? I have heard the jolly Fox-Chacers talk much about it.

MADAM, said I, what they mean by it, I don't understand; but I suppose it must be some very *long Moon*, which shines a great while about the Hunting-Season, and so hath become eminent that way, tho' this can't always so happen: But if you will please to go to the Globe yonder, you will easily see, that when the Moon is in *Cancer*, her *Sweep*, or the Ark which she makes above our Horizon, will be vastly larger than when she is on the other opposite Side of the Equator in *Capricorn*; and if it then happen to be *full Moon*, or pretty near it, (as will be the Case next *October*) the enlighten'd Ark of her Motion above the Horizon will be very large and conspicuous, in comparison of what she will run when her *full* shall happen to be in *Capricorn*. Also she will rise for several Nights nigh the same Point of the Compass, because 13 Degrees on either side of the Tropick has very nigh the same Declination with the Tropick: But the Moon's
Lati-

Latitude won't much help to account for this Phenomenon; for *that* is greater at her *Quadratures*, *i. e.* when she appears an Half-Moon, than at the *Syzygies*, as we call them, *i. e.* at *New* or *Full Moon*; or when the Sun, Moon, and Earth are all nearly in one Right Line.

I THINK I apprehend this, said the Lady; and now for the rest of my Questions. What is the *Diameter* and *Magnitude* of this Planet? What is her Motion? What Proportion doth she bear to our Earth? And do you think she is inhabited as we are?

HER Diameter, Madam, said I, we reckon to be almost 2200 Miles; in Degrees, when taken with an Astronomical Instrument, it is about 32 Min. 12 Seconds, which is nearly the same with the Sun's apparent Diameter, for that is but 31 Min. 27 Seconds; her Magnitude, or rather her *Mass*, or the quantity of Matter in her, with regard to the Earth, is about $\frac{1}{10}$ part; but then the Density of her to that of the Earth, is as 9 To 5; so that if she hath any Inhabitants, as I take it to be highly probable all the Planets have, they can't be of *such Constitutions* as we are. And tho' some of our Astronomers have lately concluded from some Observations made in
Eclip-

Eclipses of the Sun, that she hath an *Atmosphere*, or Air about her like our Earth; yet 'tis probably of a very different Nature from ours, without any Clouds, Rain, Hail, or Snow; because, whenever our Air is clear, we can always discern the Moon's Face, with, as well as without a Telescope, to be bright, clear, and distinct: Which I think could not well be, if her Atmosphere were like ours.

The exact time of her Periodical Revolution round the Earth, is in 27 Days, 7 Hours, and 43 Minutes, and this is call'd her *Periodical Month*; in which Course she runs about 2200 Miles in an Hour. But her *Synodical* one, as they call it, or the Time from *New Moon* to *New Moon*, is 29 Days, 12 Hours, and $\frac{3}{4}$ of an Hour.

PRAY, said the Lady, what occasions this Difference of above 2 Days and 5 Hours, between these two kinds of *Lunar Months*?

THE Reason, Madam, said I, you will easily apprehend; and 'tis this: While the Moon is revolving round the Earth in her *Periodick* Month, the Earth itself is moved on in her Orbit round the Sun almost an entire Sign, or one twelfth part of the *Ecliptic*: and therefore *that Point* in the Moon's Circle or Orbit, where the last
Con-

Conjunction with the Sun was made, will now be gotten too far to the *Westward*: for the Sun being got forward 27 Degrees from the Place where the last Conjunction was, the Moon must move forward till she overtake the Sun, which will take about the Space of two days: so that although the Moon come to the same place of the Ecliptic again in 27 Degrees, 7 Hours, 43 Minutes, yet she takes 29 Degrees, 12 Hours, and $\frac{3}{4}$ from the time she separates from the Sun till the time she overtakes him again, which is the Synodical Moon; in which time the Moon exhibits all her Phases.

I hope, said she, I shall get to conceive this a little better by degrees; but pray let me go on now, and ask you a Question or two more: I have been thinking, that the Inhabitants of the Moon must have one thing very odd and strange; and that is, that to one half only of their World *our Earth*, which I am apprised must appear as a *Moon* to them, can be visible: So that their other Hemisphere will be for ever deprived of the Advantage of a Moon's Light.

O! MADAM, said I, if your Speculations lead you into such Depths, we have you safe for an Astronomer; and I don't doubt but that will lead you also into the
Study

Study of such other Parts of Mathematicks, as, the more you know of them, the more you will find them necessary. And I could now tell you a great many surprising things about the Appearance of our Earth to the Inhabitants of the Moon; but I will not deprive you of the Pleasure of reading them yourself: you will find them fully enlarged upon at the End of Dr. *Gregory's Astronomy*, which is lately translated into *English*; which you will find among those Books, that, according to your Commands, my Bookseller sent you last Night from *London*.

VERY well, Sir, said she; I shall be impatient till I get some further Knowledge of that Matter. But we will now take our Leave of Mrs. Moon; and, if you please, go *down*, as you call it, towards the Sun: and from thence ascend
See Fig. IV. again; taking the rest of the Planets in their Order, according as this Diagram here represents them; which you have kindly drawn for me; and which you call a Scheme of the *Solar System*. Pray therefore, good Sir, tell me as much as you
Mercury. think I can understand, about *Mercury*, the nearest Planet to the Sun.

MERCURY, Madam, said I, is a Planet whose Diameter we reckon to be about
 2700

2700 miles ; and therefore he is about two thirds of the Earth's Magnitude. His Distance from the Sun is about 32 millions of miles ; and his mean Distance from us, about 22000 of the Earth's Semidiameter, or 88000000 miles, according to *Cassini's* Numbers. He revolves round the Sun in something less than 88 days, with the Velocity of 100000 miles in an Hour ; which is almost as fast again as the Earth travels : for we don't go above 56000 miles in that time ; and yet that is making pretty good speed too ; for that don't want much of 1000 Miles in a Minute, or 15 miles in a Second ; or in that space of Time in which you can distinctly pronounce *one, two, three, four*. And yet however amazingly swift this may seem, 'tis crawling like the *American Ignavus*, or Beast called the *Sluggard*, in comparison of the Velocity of the Rays of Light, which certainly move about 180,000 miles in that time.

WHAT ! in a Second ? said she : Let me see——why, that is almost 50000 miles while I can say the word *Light*. For god-sake stop a little, or you will make me perfectly giddy : my Head will turn quite round. What ! have you and I then been travelling almost 2000 miles together this Morning, and I knew nothing of the matter ?

'Tis even so, Madam, said I; and you see we move easily: But if you please, I will go on. The Heat of the Sun there, is probably 7 times (Mr. *Huygens* saith 9 times) as great as with us in the hottest Summer; which is, I believe, enough to make Water to boil. You will easily see therefore that his *Inhabitants* cannot be *such* as we are; for our Bodies could by no means bear such a Degree of Heat.

OUR *Ancestors* Bodies, said she, I believe could not: but by our drinking so much *scalding Tea* and *Coffee* as we now do, I should think we are preparing ourselves to go and live there: And I suppose our famous *Fire-Eater* came from thence. There can be no Fluids sure in this Fiery Planet, much less dense, than *that* which bears his Name; and no doubt all things else are dense there in the same Proportion, or else the Sun would rarify him, and send all his Furniture off in Fume, Smoak, and Vapour.

Well! said the Lady, as much as I hate frozen Zones, and bitter cold Weather, I think this Mercurial World to be worse in the other Extream; so I will never wish for a Voyage thither.

No Madam, said I, you will find this Earth to be a much more eligible Place of Abode for People of *our make*, than any other which we yet have discover'd in the best Planet of them all. As for this we are talking of, *Mercury* is so near the Sun, that he is very rarely seen by any but Astronomers, who know how to look after him. But about St. *George's* Day last he was at his greatest Distance from the Sun, and then about 8 in the Evening might have been seen very plainly.

WELL, said she, I shall not much trouble my self to enquire after him; but I remember I saw him very plain and distinct, during the Total Darkness, in the last Eclipse of the Sun; and that shall satisfy my Curiosity, till some other Opportunity offers it self. But pray, Sir, doth the Telescope shew us any thing remarkable about him?

ONLY, Madam, that he hath *Phases*, as we call them, like those of the Moon, and sometimes appears full, and sometimes horned, like her, which you will easily conceive must be the Case of any Globe of Earth illuminated by moving round the Sun, and changing its Position, with
I regard

regard to him, and to our Eyes. It hath not been yet discovered by any Spots or Marks upon him, that he revolves round his *Axis*, nor consequently what the *Position* of that *Axis* is, tho' 'tis probable he performs that Motion in a certain and determinate Time, as the rest of the primary, and I believe all the secondary Planets do. *Venus* and our *Earth* must needs appear very bright and large to the Inhabitants in this Planet, and the former will seem 6 or 7 times larger than she doth to us, which will help to supply the want of a Moon to him in the Night. But there is one more very remarkable Phænomenon of him, and that is, that as his Orbit is within ours, he must sometimes get between us and the Sun, and then he appears like a little black Spot in the Face of that Luminary, and may very easily be observed and distinguish'd by a Telescope.

O, I am mightily pleased with this, said the Lady, and shall I ever see him in that Position?

I HOPE you will many a time, Madam, said I, for he will be there in *April* 1720, and in *October* in 1723, which is but a little while hence; and he will also be there again in *May* 1761.

WELL

WELL, said she, I will then have a full look at him, if I live so long ; and in the mean time let this *Herald* of the Gods ramble on as he pleases ; and let us talk next about *Venus*.

*Beneath the sliding Sun, who runs her Race,
Doth fairest shine, and best become the Place :
For her the Winds their Eastern Blasts forbear,
Her Month reveals the Spring, and opens all the
(Year.*

*Dryden's
Lucretius.*

*With smiling Aspect she serenely moves !
Adorns with Flowers the Meads, with Leaves the
(Groves.*

*The joyous Birds her Welcome first express,
Whose Native Songs her Genial Fire confess.*

But whither am I running? Pray, Sir, stop me a little, and tell me some serious Astronomical Things about this celebrated Planet.

THE Distance of *Venus*, said I, Madam, from the Sun is about 60 Millions of Miles ; and by some *Spots* which the Telescope hath discovered in her Face, she appears to have a Revolution round her *Axis*: The Time of which seems to be about 23 Hours. But neither *Cassini* at *Paris*, nor our Mr. *Hook* here, tho' they

plainly saw the Spots to move, were able, positively and expressly to determine the Time of her Diurnal Rotation round her *Axis*; tho' the former takes it, as I said before, to be in about 23 Hours; and therefore *that* will be the Length of her Natural Day. Her Motion in her Orbit round the Sun, is perform'd in a little above 224 Days, and her Motion in an Hour is about 70000 Miles.

THAT's pretty fair, said she, too for a Lady; but I am glad she doth not fly quite so fast as the last *Whirlegig Mercury*, however: But pray, Sir, go on.

THIS Planet, Madam, said I, Mr. *Huygens* takes to have a large Atmosphere which reflects so strong and glaring a Light, that her Body is rarely seen clear and distinct. She also hath *Phases* like the Moon; as was before observed of *Mercury*; she hath no *Satellites*, Attendants, Moons, or Secondary Planets moving round her, because, as you very justly observed a while ago, *Mercury* and she being so near the Sun, have no occasion to be enlightned by *Moons*, as our Earth, *Jupiter* and *Saturn* have. Indeed *Cassini*, in the Years 1672, and 1686, with a Telescope of 34 Feet, fancied he saw a *Satellite*

tellite moving round her, whose Diameter was about a quarter part of that of *Venus*: And Dr. *Gregory* thinks it not improbable, that this might be really a Moon to this Planet, and takes the reason of its not being usually seen, to be, the unfitness of its Surface to reflect the Rays of Light: But as no subsequent Observations have confirmed this, I look upon it no more than a Conjecture. Neither she nor *Mercury* ever come so much as into *Quadrature* with the Sun, much less to an Opposition to him; and indeed, their utmost *Elongation* from him, as we call it, or greatest Distance East or West from the Sun, never amounts to above 2 Signs; *Mercury* not going above 28, and *Venus* never above 48 Degrees from the Sun. She is much about the bigness of our Earth: And the Light and Heat of the Sun, is about 4 times as great as it is with us.

I'm heartily sorry, said the Lady, that 'tis so; for I would fain have had this beautiful Planet to have been inhabited by just such fine Gentlemen and Ladies as we have here; but I find 'twon't do; the Women wou'd be there all as swarthy as Gipsies, and fry and sweat like *Negroes* in *Africa*: Out upon it! I'm afraid I

shall find never a Planet fit to be inhabited by such People as you and I are.

MADAM, said I, take care; you are falling in with the Astrologic Whimsies; one would think you had read *Athanasius Kircher's Iter Extaticum*, which agrees with your Wishes as to *Venus*, *Mercury*, and *Jupiter*; but he makes *Mars* all Smoke and Fire, and *Saturn* nothing but dull Lead, Dirt and Nastiness, as you will find when you come to look over Mr. *Huygens's* Planetary Worlds, which I have ordered the Bookseller to send you.

YOU are always cautioning me against Astrology, said she, and I must thank you for it. But I have heard that their *beginning* with that Study, hath made some Men become good Mathematicians, and even Astronomers; Shall I name them to you, Sir? you have forgot what you have told me of some of your Friends. But enough, let us proceed, and before we have quite done with this warm Dame, will you please to tell me, why she is sometimes our *Morning*, and sometimes our *Evening Star*?

THAT depends Madam, said I, on her Position, with regard to the Sun and us; when she is in that part of her *Orbit* which
is

is below the Sun, or between him and us, then she is the *Morning Star*; but when she gets into the opposite part of her *Orbit* above the Sun, then she becomes our *Evening Star*.

AND under both those Denominations, said she, I think the Poets make her change her Sex, and turn *He-Thing*, as if she could not be as useful when of *our Gender*, as of *yours*; for thus, forsooth, Mr. *Dryden* Compliments the *Changeling*:

*So from the Seas exerts his Radiant Head,
That Star, by whom the Lights of Heaven are led,
Shakes from his Rosy Locks the pearly Dews,
Dispels the Darkness, and the Day renews.*

And so that blind Creature *Milton* cries,

Bright Hesperus that leads the starry Train, &c.

Marry come up indeed! Can nothing but Men serve you? Sure we have had Women every way as well qualify'd to be Morning or Evening Stars as any bearded Tyrant of you all.

MADAM, said I, this is only owing to Custom, which hath made it the Mens Province to write Books and make Verses, and so they compliment themselves: But however, you may be pretty easy, when

Astronomical Dialogues.

you reflect, that we usually call the *most useful* things *She's*: Our *Saxon* Ancestors and our plain honest Country Folk, now call the *Sun* himself, that Father and Governor of all the Planets, *She*; and so we agree to call Guns and Fowling-Pieces; nay, our Sailors are so well bred, and such Lovers of your Sex, that they call a Ship *She*, tho' she be a *Man of War*.

WELL! said she, this is some kind of Atonement and Satisfaction; and therefore at your desire, I will for this time forgive the Gossips of *Phosphorus* and *Hesper*; but if they should attempt to make a *Man of the Moon*, I will never pass it by, for I can hardly be reconciled to those that place a *Man* in that Planet. But have you any thing further to tell me about *Venus*?

*Venus in
the Sun.*

ONLY, Madam, that *She* also sometimes, like her Neighbour *Mercury*, hath appeared like a Spot in the Sun; as you will easily conceive she may, when you consider that the Orbit of the Earth includes her's within it; and that therefore she must be sometimes, tho' very seldom, between our Eye and the Sun, and then she will appear like a Spot in the Sun's Disk. The next time that *Venus* will be seen in the Sun, will be *May 26. 1761.* a little before 6 in the Morning; I wish your
Ladyship

Ladyship Health and Happiness till the time of that Observation, and that you may be then well enough to *get up* to see it.

O! Sir, said she, I can rise betimes in a Morning, for a lesser Occasion than this: and I design to see that surprizing Appearance, if it please God I live so long: But methinks 'tis a little ungratefully done of the Moon, and these lower Planets, said she, thus to eclipse him, or deprive him of any of his Light, when they receive all theirs from him; tho' I'm almost afraid our Earth doth so too: for since she is a Moon to the Moon, it must often be interposed between the Sun and Moon, and therefore for a time deprive the latter of the Light of the former.

UPON my word, Madam, said I, you begin to run great Lengths, and go deep into the very Heart of Astronomy: And if you will please to read Dr. Gregory's *Comparative Astronomy*, in the Place I before recommended to you, you will be glad to see how rightly you have reasoned. Shall we proceed next, Madam, to talk about what they call the *Superior Planets*; and in particular about *Mars*, who next *Mars*. occurs in Order?

YES,

YES, said she, we must take him in his way ; but I hope you *Astronomers* han't such terrible shocking things to say of him as the *Poets* have. Mr. *Dryden*, I remember, gives such a Description of *Him* and his *Temple*, as when I read it, chill'd me with Horror ; and what is worse still, after he had enumerated all manner of Slaughters, Famines, Plagues, &c. he adds this :

*These and a thousand more the Fane adorn,
Their Fates were written e'er the Men were born;
All copied from the Heavens, and ruling Force
Of this Red Star, in his revolving Course :
The Form of Mars, high on a Chariot stood,
All sheath'd in Arms, and gruffly look'd the God.*

NO, Madam, said I, we give him no such Power of doing Mischief in our *Hypotheses* ; but make him as calm and as gentle as any of the Planets.

VERY well, said she, then begin, and say what you please of him.

THEY account the Diameter of *Mars*, Madam, said I, to be about 4400 miles, and therefore he must be much less than our Earth : And his Distance from the Sun
is

is about 123,000,000 miles; he revolves about the Sun in 687 Days nearly, and runs at the rate of 45000 miles in an Hour.

WELL! said she, that is pretty good marching too, for a Man in Armour. Sir, pray go on.

MADAM, said I, by some Spots which have appeared in him, the Time of his Diurnal Revolution, is by Mr. *Huygens* settled exactly at 24 Hours 40 Minutes; and the Motion of those Spots hath also discovered that this Axis hath very little or no Inclination to the Plane of his Orbit; and therefore the *Martial* Inhabitants will have no sensible difference between Summer and Winter. *Huygens* thinks that the Colour of the Earth in him is blacker than that of *Jupiter*, or the Moon. His Light and Heat is twice, and sometimes thrice, as weak as what we receive from the Sun. When he is in his *Quadratures*, as they call it, that is, in the middle between his Conjunction with, or Opposition to the Sun, he appears a little gibbose, and to a good Glass almost *bisected*; but when at Full, perfectly round and distinct. The Telescope hath not yet been able to distinguish any *Moon*, or *Satellites* moving round him; but that will not be a demonstrative
Rea-

Reason that there are none at all : for as they are at a great Distance from us, so they may be but small, and reflect but a weak and small Light, and therefore may not be visible. The Proportion of Heat and Light in this Planet, in comparison of ours, is not much above half.

O ! said she, for all he looks *so red*, then I perceive the Planet is not so fiery as the Poets feign the *God of War* to have been. Pray, Sir, let us go on to *Jupiter*.

Jupiter.

See Fig.
IV.

THIS, Madam, said I, is the largest of all the Planets, and you see by the general Scheme, that he is much more remote from the Sun, than any of the Inferior Planets we have already been discoursing of, and therefore Heaven hath granted him a supply of Light, by 4 Moons or Satellites, which revolve round him as our Moon doth round us ; and these Moons, like the Satellites of *Saturn*, are so much less than their primary Planets, that they are not visible without long Glasses, and therefore were perfectly unknown until the last Age.

These secondary Planets suffer four kinds of Eclipses. (1.) When they are within the Shadows of their Principal. (2.) When the primary Planet is between them and us. (3.) When they are between their Primary
one

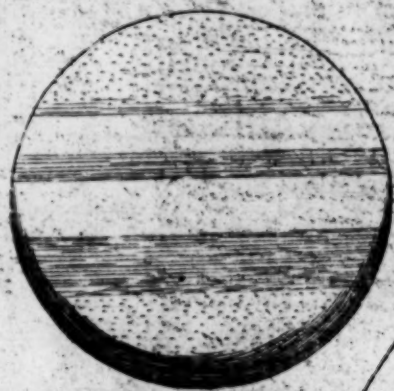


Fig. II.

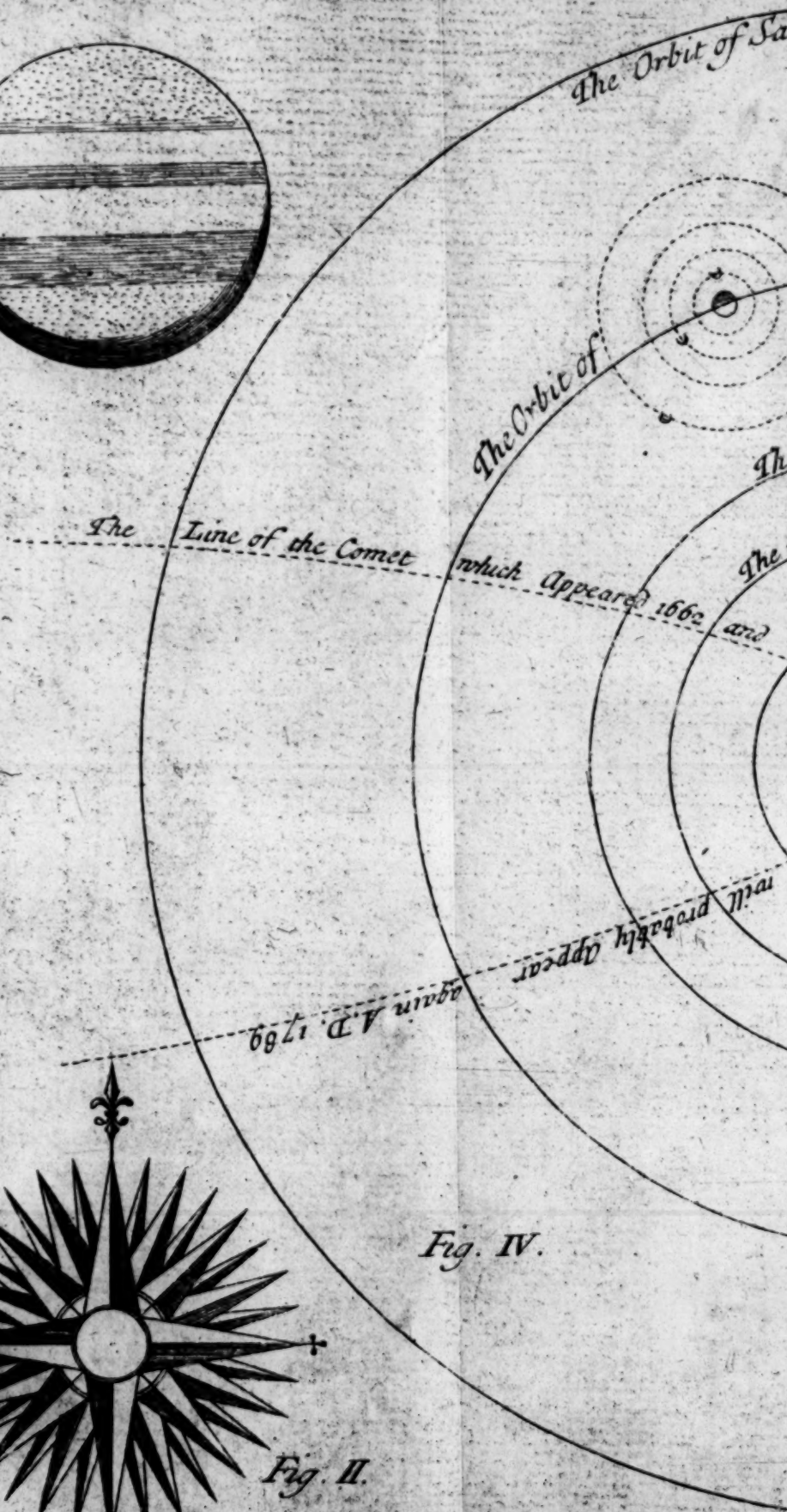
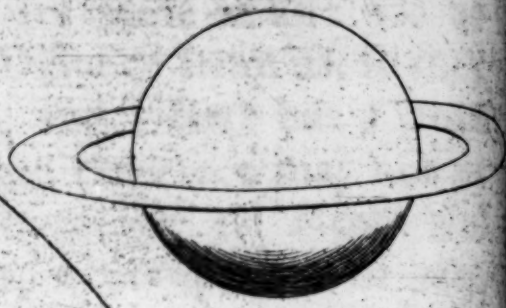


Fig. IV.

of Saturn, with his Ring, and 5 Moons



Jupiter and his 4 Moons

The Orbit of Mars

The Orbit of Earth

The Orbit of Venus

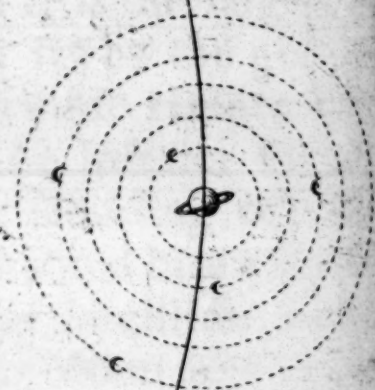
The Orbit of Mercury

The Sun

and the Moon will appear again A.D. 1758

the Comet which appeared 1664, and 1680, and 1681. Its Period is 57 1/2 years

The Trajectory of the Comet which appeared 1664, and 1680, and 1681.



2

one and us ; for then 'tis difficult to distinguish of two Luminous Points one from the other. (4.) When they interpose between one another and our Eye, so as to hide one another from our Sight ; which indeed happens but very rarely. And all these Attendants or Satellites, as well as *Saturn's*, like the Moon, the Earth's most obsequious humble Servant, do always turn their Faces towards their Lords the primary Planets, about whom they revolve, and on whom they wait.

THIS, said she, exhibits a good Image of respect and regard in Servants and Attendants ; I wish our Earthly ones would imitate the Celestial.

MADAM, said I, the Times of the Periodical Revolutions of *Jupiter's* Moons round about him, are as follows :

The innermost moves round him in 1 Day and 18 Hours, the second in 3 Days 13 Hours, the third in 7 Days and almost 4 Hours, and the outermost in 16 Days and 16 $\frac{1}{2}$ Hours. In the *Lexicon Technicum*, you will find a good deal more about this Planet, and how the *Eclipses* of his *Satellites* are calculated ; and thence arises an easy way to find the Longitude on Shore : But I doubt it is not practicable at Sea.

Sea. If this Evening happen to be clear, (as it promises well) I will shew you the Planet with his Attendants about him.

I SHALL long to see that Sight, said she; but pray go on, and tell me more about this noble Planet.

HIS Diameter, Madam, said I, is above 80,000 Miles; and the Quantity of Matter in him is about 220 times greater than that of our Earth; and his Distance from the Sun about 424 millions of Miles: He revolves round his own Axis in 9 Hours and 56 Minutes, and about the Sun in 11 Years and 10 Months: And so large is his Orbit, that he moves after the rate of about 24,000 Miles in an Hour.

THIS Planet, said she, makes a great Figure by the largeness of his Bulk, and the grandure of his Attendants; but pray what kind of Temperament hath the Air of *Jupiter*? I doubt it must be much colder than ours, and then I shall never desire to be a *Jovian*.

MADAM, said I, the Heat and Light of the Sun can't be above a 27th Part of what we enjoy here, and therefore it must be very dark, dismal, and cold living there;
and

and the weight of all Bodies will be double to what they are on our Earth.

NAY, said she, if the People be twice as heavy, and almost 30 times as cold as we are, even let them live by themselves for me; I'll never hanker after going thither, but content myself with some *jovial* Friends here in our dirty Planet, as Dr. *Burnet* call'd it; but I shall never have much value for his Judgment any more, that represented *Jupiter* as the Pattern of the fine *Antediluvian* World. But pray, Sir, What Distance may these 4 Moons of *Jupiter* be from his Body?

THE nearest, Madam, said I, is about 130,000 Miles from that Planet; the second about 364,000; the third 580,000; and the fourth or outermost is about a million of Miles distant from him.

WHAT a fine Appearance must these four Moons make, said she, and what frequent Eclipses of the Sun, and of one another, do they produce! And if *Jupiter* hath any Ocean, and it ben't always frozen up like the *Baltick* in a hard Winter, what whisking Tides must they produce *there*, since our own Moon hath so great an Effect *here*, in that respect!

I

MADAM,

MADAM, said I, I see you don't only advance in *Astronomical*, but even in *Physical* or *Natural* Knowledge: That Speculation about the *Tides* of *Jupiter* is curious and new, and will be worth a further pursuit. But if you please, we will now go on with our Planet's *Phænomena*. You see by the *Figure of Jupiter*, that besides a famous Spot by which his Diurnal Motion was determined, there are Appearances in him like Swathes or *Belts*, as they call them: These they take to be moveable, and to be formed by the Clouds of this Planet, which seem, like our Trade-Winds, to lie in Tracts parallel to the *Equator* of *Jupiter*.

AND if these are really Clouds, says she, won't it be a proof of *Jupiter's* having a vaporous Atmosphere about him, like that of our Earth.

IT will doubtless shew, said I, Madam, that he hath something round him like our Air: but its Texture, Gravity, and Elasticity may notwithstanding be vastly different from that of Ours; but if by it you mean to insinuate *that he is inhabited*, I entirely agree with you; for I take it, that such an *Apparatus* as the making four
Moons

Moons to revolve about, and to enlighten him; (as five such there are also moving round *Saturn*, besides his Ring) I take this, I say, to be a demonstrative Proof of both these Planets having *some kind of Inhabitants*, who have Eyes to stand in need of *Light*, as well as *other Senses* proper for their Natures: For we never find Nature doing any thing in vain, but ordering all things with the most consummate Wisdom; and we must never believe she would form Moons, where there are no People to be lighted by them.

Do you think, said she, that our Earth can be seen by the *Jovial* Inhabitants?

No, Madam, said I, by no means.

LORD! what vain Creatures we are, said she, in this Earthly Planet? What a bustle do we make to extend our Power and Empire over it? But I'm mighty glad the impertinent and destructive Ambition of an *Alexander* or a *Louis le Grand*, can't be heard of in *Jupiter*; and I hope the Heroes *there* are always exerting themselves for the good of their People. How vain is it also in some of our Divines, to suppose *Jupiter*, as well as the rest of the Heavenly Bodies, to be made *only* for
K the

the use of Mankind? When yet, neither in him nor in *Saturn*, can the Place of our Habitation be seen. But pray, Sir, go on.

THIS, Madam, said I, I think is all that is very remarkable about this famous Planet, except one thing more, which is indeed very considerable and surprizing: And that is this; that by the Eclipses of *Jupiter's* Satellites, made by the Interposition of his Body between them and our Eye, it hath been discovered that Light is in its Motion *Progressive*, and not *Instantaneous*, but that it takes up a determinate Time to come from *Jupiter* to our Eyes: For they have observed that these Eclipses happen *sooner* than they ought to do, by Calculation, when *Jupiter* is nearest to the Earth; and when *Jupiter* is farthest removed from our Earth, then those Eclipses do not happen so soon as they should do by Calculation. The difference between *Jupiter's* nearest and farthest Distance from our Earth is the Diameter of the annual Orbit, and the Difference of the Eclipses of *Jupiter's* Satellites appearing sooner or later than the Time by Calculation; and those Differences being still the same, according to the Distance of *Jupiter* from our Earth, it is therefore exactly found by
 Obser-

Observation, the Time that Light takes to move the length of the Diameter of the annual Orbit of our Earth. And by those Observations it is found that Light moves from the Sun to us in $7\frac{1}{2}$ Minutes of Time : And on this Calculation it was, that what I told you before about the prodigious Velocity of the Rays of Light, was founded.

I SHALL look a little further, said she, into this Affair some other time ; but, pray, let us now go on to talk about *Sa-Saturn.*
turn.

THAT outermost Planet in our System, Madam, said I, is at a very great Distance from the Sun, about 777 millions of Miles ; and the Time of his Revolution round him, is about 30 Years, or more exactly speaking, in 10759 Days, 6 Hours, and 36 Minutes : And yet so very large is his Orbit, that he moves at the rate of about 18000 Miles an Hour ; his Diameter is about 61000 Miles ; and with regard to the Quantity of Matter in him, 'tis about 94 times as great as that of our Earth ; but his Density is not much above a 7th part of that of the Matter of our Planet. And as to Light and Heat, 'tis probable that he hath not above a 90th

part of what we enjoy by the Sun. Indeed in order to supply this great Defect of the Sun's Light, occasion'd by so great a Distance, our All-wise Creator hath furnish'd him with *Five Moons* or Attendants; the largest of all which, and which is the only one that is commonly seen, is the 4th in order from his Body; and he bears the Name of the *Huygenian Satellite*, because first discover'd by Mr. *Huygens*. These Satellites of *Saturn* revolve round him in the *Plane* of his Ring (of which Ring I shall speak presently) and so their Circles make the same Angle with his Orbit, that the Plane of his Ring doth, which is about 31 Degrees. But the Orbit of *Saturn* himself is nearly coincident with the Plane of our Earth's Ecliptick, as are indeed the Orbits of all the primary Planets. It doth not yet, I think, appear, that *Saturn* hath any Diurnal Revolution round his own *Axis*; the Time of his Periodick Motion round the Sun, I gave you before; and those of his Satellites are as follows: The Innermost of these Moons revolves round *Saturn* in one Day, 21 Hours and 20 Minutes, and is distant from him about 146,000 Miles. The second is distant from him about 187,000 Miles, and performs his Revolution in 2 Days, 17 Hours and 40 Minutes.

The

The third's Revolution takes up 4 Days, 13 Hours and 45 Minutes, and he is distant from the Centre of *Saturn* about 263,000 Miles. The *Huygenian* Satellite is about 600,000 Miles from him, and moves round him in 15 Days, 22 Hours and 40 Minutes. The last is 1,800,000 Miles distant from *Saturn*, and takes up 79 Days, 22 Hours, in revolving round him.

'Tis highly probable that there may be more Satellites than these five moving round this remote Planet ; but their Distance is so great, and their Light may be so obscure, as that they have hitherto escaped our Eyes, and perhaps may continue to do so for ever ; for I don't think that our Telescopes will be much farther improved.

But the most surprizing and unparallel'd *Phænomenon* of all, in this Planet, is that which we call *his Ring* ; which appears nearly as the Figure represents it, in an ordinary Telescope : 'Tis a vast Body of Earth, as is most probable, of perhaps 7 or 800 Miles in thickness, which at the Distance of about 21000 Miles from *Saturn's* Body, and with just as great a breadth, is placed in a circular Arch, round about the Planet, in figure much like the great wooden Crane-Wheels, in

Vid. Fig.
of Saturn.

which Men or Horses walk, to raile Goods, or to draw Water. 'Tis placed exactly over the Equator of *Saturn*, and is not any way contiguous to his Body, nor supported by any thing. The *Surface* of this Ring is not rough and full of Hills and Protuberances, as *that* of the Moon in most places is; but even and plain, as it is in those Regions of the Moon, which some, because of their great Evenness, have judged to be *Seas*.

THE Thickness of the Ring, comes not into Astronomical Observation, appearing but as a Line. And tho' the two broad Surfaces of the Ring reflect a good deal of strong Light, yet the marginal Surface of it, or its Edge or middle Part between the two eminent Surfaces, reflects hardly any at all. The Plane of the Ring is inclined to that of the Ecliptic, with an Angle of about 31 Degrees; and this Inclination in the Course of one entire Revolution of *Saturn* round the *Sun*, hath some Variation; being twice *greatest*, and twice the least of all. And this occasions the Planet sometimes to appear without any Ring at all, as when the *Sun* happens to be in the Plane of the Ring; and at other times, with *Anse*, as they call them, or *Handles* only; when
but

but little of the Surface of the Ring can be seen : And at all other times the Ring will appear in an Oval Form, which sometimes will be more, sometimes less oblong.

I suppose, said the Lady, it is at that critical Time when the *Ansa* only appear, that *Saturn* puts on the Figure which *Hudibras* makes *Sydrophel* give him, that is, that 'tis like a *Tobacco-Stopper*.

THAT is but a mean Ridicule, said I, Madam ; but I perceive it hath some Use ; for it impresses itself, and the Thing, stronger on the Memory, than perhaps a more just and serious Description would have done. But your Ladyship will soon be above these little Helps : And you will receive a great deal of Pleasure, Madam, by reading what Dr. *Gregory* hath written about this Ring, in his Discourse of *Saturn*, and in his *Comparative Astronomy*, so often recommended to you ; where the most considerable Phænomena of this *Ring*, and of the *Satellites*, as they appear to an Eye supposed to be placed in *Saturn*, are explained and accounted for ; or you may consult the *Lexicon Technicum*.

I WILL, said she, attach my self heartily to that Book, as soon as I can : And after we have view'd this Planet with our Telescope, which I will sit up any time of the Night to do, if you can afford me your Assistance. For these two superior Planets have so many Wonders attending them, that I grow seriously amazed ; and long to understand a little more of them, and to contemplate these wonderful Works of our great Creator. And indeed what a vast Field of Thought, what a new World of Speculation, do these new Discoveries open to us ! How empty and starv'd is a Mind unfurnish'd with such glorious Ideas !

What a rich Fund of Images is treasured up *here* to embellish our Poetry ? And yet I don't remember to have met with many Allusions taken from these Things, except in a late Copy of Verses presented to her Grace the Dutchess of *Bolton*, where after the Poet had said a great many fine and just things of her, I now remember these Lines ; the Beauty and Propriety of which, did not at first strike me so much as they do now, since I have been conversant with these Speculations.

BOLTON'S

*BOLTON's the Centre of Respect and Love ;
Round her, like Planets, we at Distance move :
From her receive our Light, derive our Heat,
And still tow'rds Her we tend and gravitate,
Just in Proportion to our Sense and Weight.* }

But now, Sir, said she, if you please we will leave off, *unbend*, and go to our Tea.

THE Lady plied her Telescopes, and pursued her Astronomical Studies with great Application and Success; and after some time, when I had the Honour to wait upon her again, she took me out into the Summer-house in the Garden, and then began thus with me.

SIR, said she, you have already taken a great deal of pains to gratify a Woman's Curiosity ; but I must beg you to indulge me yet a little further, and to afford me a Lecture upon another Point ; about which, as I am ashamed to trouble you, so I should be afraid to ask you, but that you have been so kind already, as to help me to get rid of many Fears and Terrors, too incident to our Sex : And if you can ease my Mind of this remaining Dread, I shall think you can do me a signal piece of Service.

You

You must know I have been tumbling over those Books of Astronomy, which you have bid me read; and tho' there be very many Things that I don't understand fully at present, yet there are some also that I know enough of, to be put into the Vapours by them.

The *Affair of Comets*, Sir, with their grisly *Beards* and horrid *Tails*, fright me almost out of my Wits: For god-sake therefore, tell me, as plainly as you can, whether my Dread is well-grounded; Do they really *forebode* all manner of Mischief to Mankind, as well as *do* a great deal, when they come among us? What are they? Are their Motions natural, and accountable by Mathematical Calculation, as those of the Planets? Or are they miraculously sent hither as the Messengers of God's Wrath, and as the Executioners of his Judgments upon sinful Mankind?

MADAM, said I, as to their *Presages*, I take them to be entirely groundless; but they may be made (as almost any other of the Heavenly Bodies may, if God please) to become the Instruments of Evil and Destruction to any of the other Planets; but indeed it doth not plainly appear, since their Motions and Appearances have been of late more fully

enquired into, that they *have any such destructive Use*, or that they have actually done any real Mischief in the Planetary World. There have indeed been some such *Conjectures*; but as I take them to be *no more*, I will not trouble you with them now; because I believe they will occur to you in your future pursuit of these Studies.

I'm glad to hear you say so, said she, and I begin a little to be comforted: But pray go on, and compleat my Cure; for I don't care to be *drown'd* or *burnt* up by one of these extravagant Ramblers, a Comet, before I am aware.

O MADAM, said I, I perceive where you have been dipping; I will therefore give you the most satisfactory Account I can.

THE Ancients, you must know, generally believ'd *Comets* to be only *Meteors*, like our *Firedrakes*, &c. and that they were no higher than our Regions of the Air; while some modern Writers placed them among the fixed Stars. But subsequent Observations, with good Instruments, and the Application of the Laws of Motion and Geometry, to Astronomi-
cal

cal Enquiries, have now satisfied us almost to a Demonstration, that they are a *kind of Planets* revolving in determinate Periods round the Sun : But indeed the Orbits of many of them are so very oblong, *excentric* or *oval*, as well as large and extended, that they can appear to us but very seldom ; and when they do become visible, they exhibit Appearances which are very surprizing ; for the lower ends of their Orbits are so very near the Sun, that when they come down into that part, or into their *Perihelion*, as 'tis call'd, they are actually heated and set on fire by him to such a degree, as not to get off again, without such dreadful *Beards* and *Tails*, as would really fright such as don't understand and consider how they come by them.

BLESS me! said she, why then if our Earth moved in such an Orbit, I see we might be easily destroyed and burnt up, by that very Sun, who now gives us cheering Light and kindly Heat!

'TIS very true, Madam, said I ; for that great Comet which appeared here in the Year 1680, (and which I saw, and very well remember, tho' then but a Boy) went so near to the Sun, as to
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acquire a Degree of Heat above 2000 times as great as that of red-hot Iron : And if its Body was about the Size of our Earth, as it was judged to be, it won't be cool again this Million of Years. And yet it pleased God, that that Comet went away from us, without doing us any sensible Harm, that I know of; and so little do I fear being hurt by any of them, that I could almost wish another would appear, to help us to compleat the Theory of their Motions.

NAY, said she, if you that know so much of them are not afraid of them, I'm sure I won't be so for the future : Pray therefore, Sir, proceed, and tell me what you can of the Number, Motions, and Appearances of these Comets, how their *Beards* and *Tails* are formed; and how you account for the most eminent of their Appearances.

MADAM, said I, there have within this last 400 Years appeared to this part of the World but 24 Comets, (how much greater a Number there may be, God knows, and perhaps subsequent Observations may discover more.) And of these, according to the Observations of Dr. *Halley* and other Astronomers, *three*
3 of

of them have had their Orbits and Appearances so *very like*, and the Times of their Appearing so *very equal*, that they have judged it very probable that those three Comets, which successively appeared as three, were in reality but one or the *same Comet* appearing at three several times.

And the like they are inclined to judge of two others; that they also are but one, appearing at two different times.

That great Comet that appeared here in the Years 1680, and 1681, was seen before in our Hemisphere, *A. D.* 1106; once before, about the Year 532; and also 44 Years before our Saviour's Birth: And therefore they conclude the Time of its Periodick Revolution round the Sun to 575 Years.

*The Orbits
of these
three are
described in
Fig. IV.*

The Time of the Revolution of *another Comet*, which they judge will appear again *A. D.* 1758, is 75 Years: *Another*, which probably may be seen here again, *A. D.* 1789, makes its *Ellipsis* round the Sun in 129 Years.

WHAT Bigness do you take these Comets to have been of, Sir? said the Lady.

MADAM, said I, they are generally of the size of the rest of the Planets, and have

have Atmospheres about them like our Earth: But then as all our Planets move pretty nearly in the *Plane of the Earth's Ecliptic*, these *Comets* are tied to no such Rules; for the *Planes of their Orbits* have very different, nay, almost all manner of Directions and Positions, and their Motions are all manner of ways; some from East to West, others from West to East, some from South to North, and others a quite contrary way, &c. And yet their Motion is equable enough, and shews us this great Point; that as there can be no such solid Orbs as was imagined in the *Ptolemaic System*; so there can be neither any such thing as a *Plenum*, and no such *subtile Matter* as the *Cartesians* have invented, to solve their *Hypotheses*: But we may fairly conclude, that all the vast Spaces both between and beyond the Planetary System, are filled with no Matter capable of making any considerable Resistance to their Motions, but rather are an immense Void, or Vacuity.

I think that is a very probable Conclusion, said she; for if there were any quantity of resisting Matter, it must always obstruct a little, and by degrees must make very sensible Alterations in the Planets Motions; which I don't find to have been
in

in Fact discovered ; but sure, Sir, these Comets must go off to vast Distances from the Sun ?

Y E S, Madam, said I, and therefore they are still more unfit than any of the other Planets, to be inhabited by such kind of Beings, as those of human Race ; for the middle Distance of the Great Comet that appeared in 1680, was more than 5000 millions of Miles from the Sun ; as its greatest Distance was above twice as much ; and yet its least Distance was not above a 20,000th part of its greatest : so that in its whole Revolution, it would be subject to such Extremities, as that its *greatest* Degree of Light and Heat to its *least*, were above 400 millions to one. And yet notwithstanding this immense Extension of its *Ecliptic Orbit*, the Great and All-wise Architect of the Universe hath probably so adjusted the *Centrifugal* and the *Centripetal* Forces, that it doth not quite leave the Sun, tho' it go so far from him, but returns again towards him, and revolves round him in a determinate Period of Years. *None of the Orbits* of any of these Comets yet known, are in or near the Plane of the *Earth's Ecliptic* ; and therefore in their *Ascent* from the Sun, tho' heated never so

so much by him, yet they won't come near enough to our Earth to *burn* us, or affect us with any sensible Heat; and therefore, Madam, your Fears of being *burnt in your Bed* by a Comet, I hope will vanish for this time.

WELL, said she, and so they will; but I love to know the Reasons of things as well as any Man of you all. But pray, Sir, what are the *Heads, Beards, and Tails* of these Comets?

MADAM, said I, the Bodies of Comets are probably in Substance like our Earth; fixt, solid, and compact: Their Tails are probably long and very thin trains of Smoak and Vapours, emitted from the heated or enkindled Body, Head, or *Nucleus*, as some call it, after their *Perihelion*, or after their having been at their nearest Distance to the Sun; for then it hath been observed, that the *Tails of all Comets* have appeared *largest and longest*. In the *Lexicon Technicum*, under the word *Comet*, you will find a great deal said about the *Phænomena* of Comets, their *Beards, Tails, &c.* from Sir *Isaac Newton*, and other Authors; and there you will likewise find Conjectures about their Use in the Planetary System.

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SIR,

SIR, said she, I shall have recourse to those Books with a great deal of Pleasure, and will trouble you no farther now with my Enquiries: I see Company appearing, let us forget our Astronomy a while, and trifle with them as agreeably as we can.

ABOUT a Month after our last Conference, I waited on the Lady in *London*, who after the usual Compliments, began thus with me.

THO' you might be justly afraid to meet such a questionnaire Creature as I am, I will own, I'm glad to see you in this Place; for I have a great many things to enquire of you, with relation to our late Conferences in the Country. Ever since that, I have been tumbling over Astronomical Books with the utmost Application; I have dipt a little also into the *New Physics*, and I have been running over *your* Geometry, *your* Trigonometry, and *your* Spherick Projection, in order to use myself to Figures, and to get clearer Ideas of what the Astronomical Writers say: And tho' I believe I should have been frightened and deterred from beginning with *Geometry*, and the *abstracted Mathematicks*, yet I now find them so necessary, that I
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Minds, can have no Notions of the Rapturous Pleasures of Science.

I ENTIRELY agree with you in your Notions, Madam, said I, and your Commands shall be my Delight as well as my Duty ; in the mean time, can I serve your Ladyship in any thing now ?

YOU are very obliging, said she, to anticipate your Trouble ; but we will lose no time in Compliments : What I want at present, is, to be instructed farther by some *Diagram or Figure*, how by the Earth's revolving round the Sun in her Annual Motion, together with *that* round her *Axis*, the different Seasons of the Year, Length and Decrease of Day and Night, &c. are accounted for. Have you drawn me such a Scheme as you once promised me, for this purpose ?

I HAVE, Madam, said I, and here it is ; I took it chiefly from Mr. *Flamsteed's Doctrine of the Sphere* ; a Book, I dare say, your Ladyship will one time or other dip into.

I HAVE seen it, said she, in Sir *Jonas Moor's Mathematicks*, and perhaps may consider it further ; for tho' I never de-
sign

sign to attempt the Calculation or Construction of Eclipses, yet I shall be glad to know how the Astronomers do it. But, pray, Sir, go on, and explain the Figures to me.

An Explication of Fig. V.

LET the Circle A B C D represent the *Earth's* Annual Orbit round the Sun, whose Centre is supposed to describe that Periphery, as it moves round the Sun from A towards B, in the Natural Order of the Signs, and from *Aries* to *Taurus*, &c.

THE Line γ , $\odot$, $\simeq$, represents the *Equinoctial Colure*, and the other $\S$, $\odot$, $\wp$, standing at right Angles to it, is the *Solstitial Colure*.

The 4 lesser Circles *d o t i* represent the *Earth's* quadruple Position in the 4 *Cardinal Points*, as they call them, *i. e.* at the 2 Equinoxes, and the 2 Solstices, and the Line *d t* at right Angles to the Colures, may fitly enough be called the *Horizon of the Earth's Disk*, because it separates that half part of the *Earth* which the Sun shines on, from the other which lies behind in the Dark.

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BUT

BUT, pray, said she, what do you mean by the Earth's *Disk*?

I USE the Word, Madam, said I, because you will frequently meet with it in your reading; it signifies that round appearance of the Sun, Moon, or Earth, which we suppose to be the Object of any Spectator's View; and therefore the Earth's Disk is the appearance of that half of it, which because it is enlightened by the Sun, is seen by any remote Beholder.

VERY well, Sir, said she, pray go on.

IN these 4 Figures of the Earth, the Spectator's Eye is supposed to be below under the Earth's Centre *e*, which Centre always moves in the Circle *A B C D*. To an Eye so placed, the Circle *d o t i*, which divides the Earth's Upper Hemisphere from the Lower, will appear to lie in, or be *coincident* with the *Plane* of the *Ecliptic*; and therefore that may be called the *Ecliptic on the Earth's Globe*.

THE *North Pole* of the Earth, or the upper End of the *Axis*, about which her Diurnal Motion is made, will then appear to be at *P*, $23^{\circ} 30'$ distant from *e* to the

the Pole of the Ecliptic ; and if you draw a Line thro' those Points connecting the two Poles, that may be called the Line of *Direction of the Earth's Axis* ; and if produced, it will be coincident with, or parallel to the great *Solstitial Colure*, and therefore will describe *such a Line* on the Earth, to which, when the Sun's Rays run parallel, or whenever the Earth's Centre is in the Points ϖ or $\S$, then will the *longest*, in the latter, and the *shortest Days*, in the former Case, happen to all the Inhabitants of the Earth.

This Line of Direction *P e*, is always found parallel to the Line $\S$, $\odot$, ϖ , during the whole annual Revolution of the Earth.

P R A Y, said she, what occasions this *Parallelism of the Earth's Axis* ? which I have read much of.

M A D A M, said I, 'tis not any *new Motion*, superinduced into the Earth, but only her keeping to the first Position or Direction of that Diameter about which she revolves ; which she must always do, without it be chang'd by the Will of the Great Creator, who at first appointed it to be so as it is. But if you please, I will go on.

A Line drawn perpendicular to the Earth's Axis, will represent on the Earth the *Equinoctial Colure*, and will always be parallel to the Great Equinoctial Colure, γ , $\odot$, $\simeq$; and whenever the Sun's Rays run parallel to this Line, which they will do, whenever the Earth is in γ or $\simeq$, then will the *Days and Nights be equal* all the Earth over; For you see that as the Earth revolves round its Axis $t P e d$, all Circles described on the Earth, from the Pole P , *i. e.* such as are the *Equator* and all its Parallels, will be just one half in the Light, and the other half in the Dark.

The Angle made between the Earth's Axis and that of the Ecliptic, may be *Fig. VI.* learnt best from *Fig. VI.*

In which the Ecliptic Line $\gamma C \simeq C$ represents the Earth's Annual Orbit, as view'd by the Eye, at a vast Distance, and when the Eye is placed a little above its Plane: Here let e be the Pole, and $e d$ be the Axis of the Earth's Ecliptic, which you must suppose to be every where at right Angles to the Plane of the *Great Orbit*; and let P be the Earth's North Pole, $P m$ the Earth's Axis, about which the Earth turns from West to East in 24 Hours; and suppose the Angle $P C e$ to be always the same, *viz.* $23^{\circ} 30'$.

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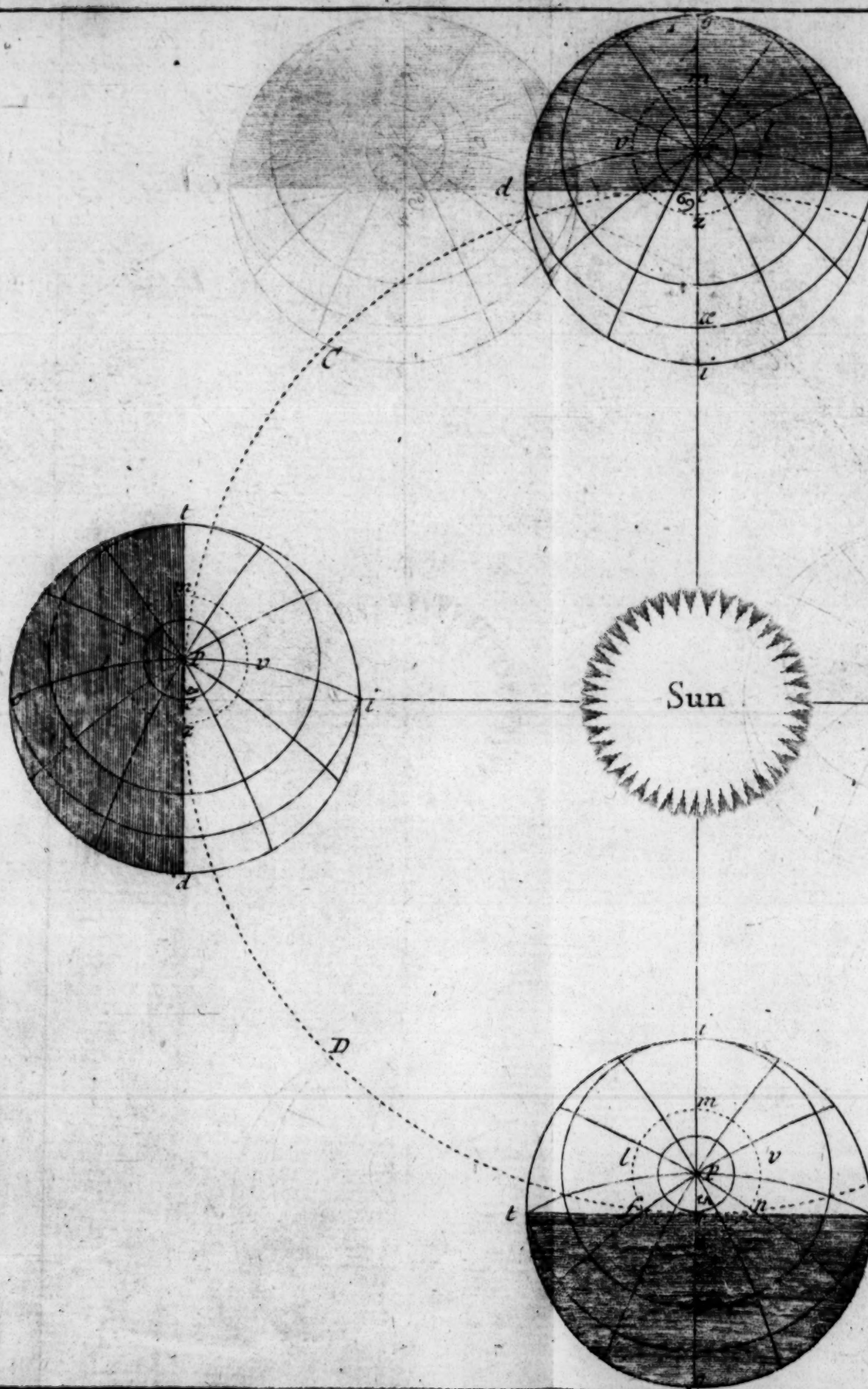
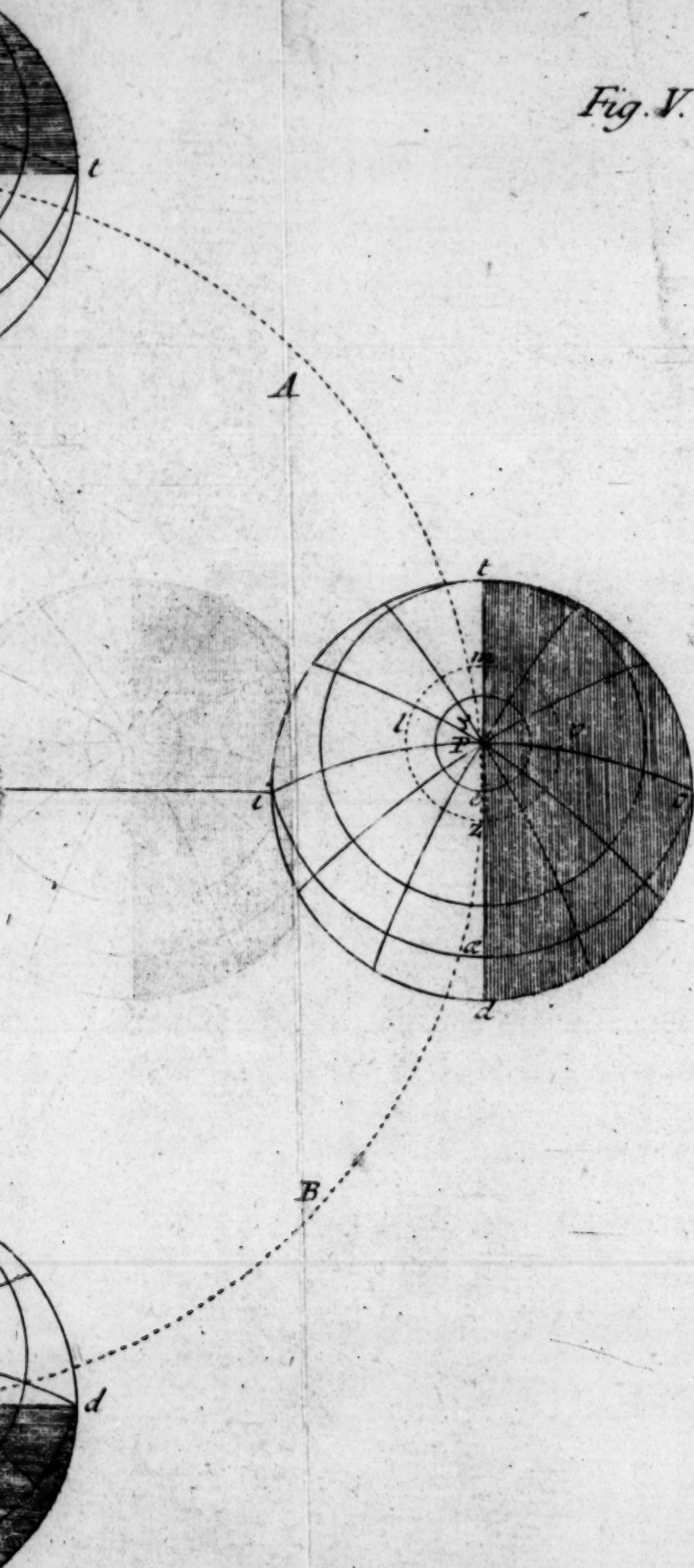


Fig. V.







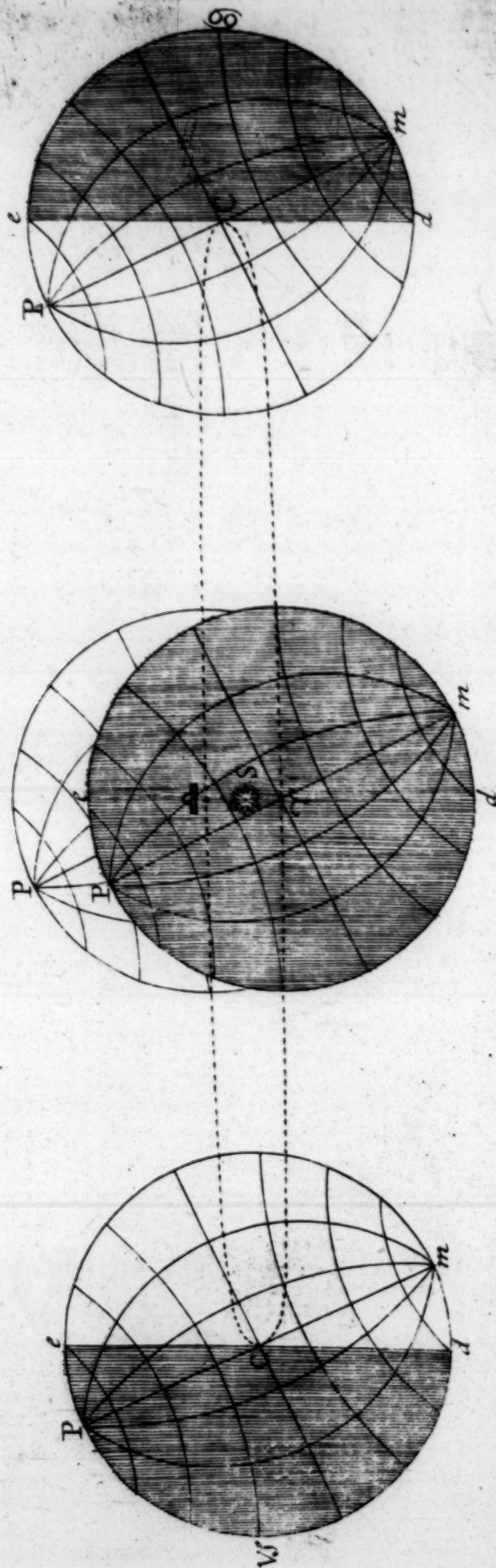


Fig. VII.

These things being supposed, it will be plain, that every Point on the Earth's Surface, will, as the Earth revolves in her Diurnal Motion, describe a Circle about the next Pole: And when you consider, that every *such Point* is *Vertical* to the Earth's Centre, and answering to what hath usually been called the *Zenith*, or *Vertex*, in the *Ptolemaic* Projections, the Circle so described, is very properly called the *Path of the Vertex*, because 'tis a Track or Line made by the Motion of that Point.

I FANCY I shall conceive this right, said she, when I get to my Globe; for then if I bring *London* into the *Zenith*, the Point on the Globe representing *London*, is, I suppose, what you call the *Vertex*; and if I turn the Globe round its Axis, I see that Point will describe a Circle, parallel to the Equator; and such a Parallel, I take it, you call the *Path of London*.

EXACTLY right, said I, Madam, and no one could have explained it better. I think then, we shall now go on with pleasure.

In such Projections as these four Figures of the Earth in *Fig. V.* a Circle equally distant from both the Poles, must be the Earth's *Equator*; and the Distance of any Place

Place from that Circle, will be the *Latitude* of that Place; and therefore half the Diameter of any *Path* will be the Sine Complement of the *Latitude* of any Place, describing that Path.

If you take any Place on the Earth, and make a Circle pass thro' it, and the two Poles, that will be the *Meridian* of that Place.

That Point in the Earth's Periphery, which is opposite to the Sun, or which is found by a right Line drawn from the Earth to the Sun, is called the *Sun's Place in the Ecliptic*.

i P o, and *t P d* in *Fig. V.* represent the Earth's first Meridian, in each Pair of the opposite Circles.

m a z l, represents the Circle made by the *Vertex of London*; as that within doth the *Northern Polar Circle*; and the next without it, the *Northern Tropick*.

By the Figure it will appear plain, that since the Sun enlightens but one half of the Earth's Globe at a time, if the Earth be in α or γ , the *Horizon of the Disk* will then coincide with the *Solstitial Colure*; and therefore as the Earth turns round her *Axis*, which now is coincident with the Line *d t*, the Paths of the *Ver-*
tices,

tices, or the Equator and all its Parallels will be bisected by the Line *dt*: and while any particular place on the Earth, or any *Vertex* is in the Light Part *t id*, the Inhabitants of it will see the Sun; and therefore to them it will be *Day*: And while it is in the Dark Part, it will be *Night* to them.

But when the Earth is moved on, either from γ to $\ominus$, or from $\simeq$ to $\wp$, the *Line of Direction* will coincide with the *Solstitial Colure*, and the *Horizon of the Disk* will become at Right Angles to it on the Pole of the Ecliptic *e*. Wherefore, when the Earth is in $\wp$, all places between the two Poles of the Earth and the Ecliptic, and the *entire Artic Circle*, will, now you see, be illuminated in their whole Revolutions, as the Earth revolves round its Axis *i P o*. The *Vertexes* therefore will see the Sun, each one longer than 24 Hours, according as it is more or less distant from the Pole of the Globes; and those that lie under the *Artic Circle*, touch the *Horizon of the Disk*; and consequently at this time of the Year, *viz. June 10*, they will see the Sun 90 Degrees from the *Vertex*, both on the North and South of their Meridian; so that as soon as he is Set, he will immediately Rise again; and consequently they have no Night: But all *Paths* without
this,

this, you see, do *cut*, or get within the *Horizon of the Disk*; and so will have their Days longer than their Nights, in proportion to the Quantity of the enlightened part of their Path, to the dark one; *i. e.* at *London*, As the Ark *n v m l f*, is to the Ark *n z f*; which is above Two to One: and therefore the Days will then be above 16 Hours long, and the Nights scarce 8.

Again, while the Earth moves from α thro' w , and so on to r , you see the *North Pole* of the Earth is all that time in the Light part of the Disk; which shews you that to such as live under that Pole there will be 6 Months Day. But while the Earth runs on from r thro' s to α , that Pole will, you see, be in the dark part of the Disk; which shews that then, under the Poles, there will be six Months Night. For indeed, when the Earth is in s , all things will be the very reverse of what they are when she is in w ; *i. e.* the Nights longer than the Days, &c.

But when the Earth is in r or α , the Axis of the Earth's Revolution being *dt*, (the *Horizon of the Disk*) just one half of the Equator, and all its Parallels will be enlightened, and the other half in the Dark;

Dark ; and therefore the Days and Nights must be equal all the World over.

S I R, said the Lady, if you can part with this Figure, I will look it over more carefully another time, when I am by myself. In the mean time I have another trouble to give you, if you will oblige me in it ; and that is, to get me a sight of the famous *Orrery*, which I have heard you and others so often speak of ; and which I think was made by Mr. *Rowley*, the famous Mathematical Instrument-Maker, and Master of the Mechanicks to the King ; and whom I find you have always recommended in your Books, as the best Workman of his Profession.

I shall stay in Town about a Week longer, and will enlarge my time a day or two, rather than miss seeing so instructive and curious a Piece of Ingenuity.

M A D A M, said I, the *fine Instrument* of that Name, which Mr. *Rowley* made for the *East India* Company, is now luckily in a Place where I can come at it ; I will go thither to-morrow, and then appoint you a day when I will wait on you to see it.

The

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Again, while the Earth moves from ω thro' ν , and so on to γ , you see the *North Pole* of the Earth is all that time in the Light part of the Disk; which shews you that to such as live under that Pole there will be 6 Months Day. But while the Earth runs on from γ thro' δ to ω , that Pole will, you see, be in the dark part of the Disk; which shews that then, under the Poles, there will be six Months Night. For indeed, when the Earth is in δ , all things will be the very reverse of what they are when she is in ν ; *i. e.* the Nights longer than the Days, &c.

But when the Earth is in γ or ω , the Axis of the Earth's Revolution being *dt*, (the *Horizon of the Disk*) just one half of the Equator, and all its Parallels will be enlightened, and the other half in the Dark;

Dark ; and therefore the Days and Nights must be equal all the World over.

SIR, said the Lady, if you can part with this Figure, I will look it over more carefully another time, when I am by myself. In the mean time I have another trouble to give you, if you will oblige me in it ; and that is, to get me a sight of the famous *Orrery*, which I have heard you and others so often speak of ; and which I think was made by Mr. *Rowley*, the famous Mathematical Instrument-Maker, and Master of the Mechanicks to the King ; and whom I find you have always recommended in your Books, as the best Workman of his Profession.

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The

The Description of the Famous Instrument called the ORRERY; made by Mr. John Rowley, Master of the Mechanicks to the King.

WITHIN a day or two, I obtained for the Lady a sight of the *Orrery*; she desired we might have no other Company but one young Lady more of her Acquaintance; because, said she, I shall ask so many Questions, as perhaps will shew my *Impertinence* to those who are not acquainted with Things of this Nature, and my *Ignorance* to those who are.

As soon as the Instrument was taken out of its Case and set upon the Table, she expressed herself mightily pleased with the cleanness and cleverness of the Workmanship of it; for indeed the Outside of it is very rich and beautiful. The Frame is of fine Ebony richly adorned with twelve silver Pilasters, in the form of *Cariatides*; and with all the Signs of the Zodiack, cast of the same Metal, and placed between them; the Handles were also of Silver finely wrought, with the Joints

as

☉ *The Sun.*
 ♁ *The Earth.*
 ☾ *The Moon.*
 ♀ *Venus.*
 ☿ *Mercury.*

The



Made by M^r. John Ro

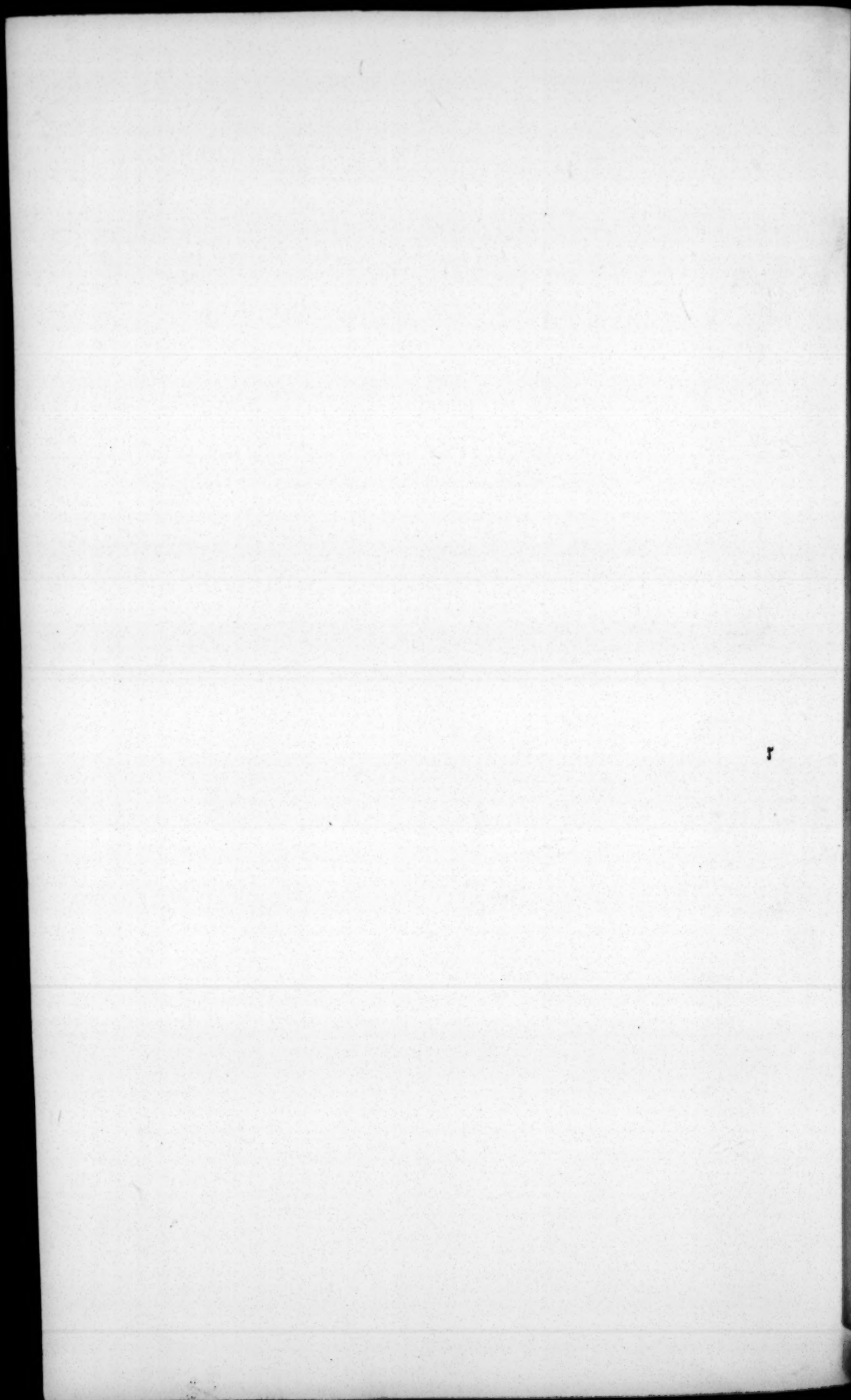
e Orrery

γ $\ominus$ $\equiv$ τ
The Eccliptick.



Rowley

M^o of Mechanicks to His Maj^{ty}



as nice as ever were seen in the Hinges of any Snuff-Box: On the Top of the Frame, which was exactly Circular like the Horizon of a Globe, is a *broad silver Ring*, on which the Figures of the twelve Signs are exactly engraved; with two Circles accurately divided; *one* shewing the Degrees of each Sign, and the *other* the Sun's Declination, against his Place in the Ecliptic, each Day at Noon.

The Nature and Use of these Circles the Lady perfectly understood, from what she had before learned; and therefore in her pleasant way, she began thus:

IF so much Art and Expence be bestowed upon the *Outside* of this curious Machine, I don't doubt but the *Inside* of it is at least equally curious and useful: And therefore I must desire you, Sir, said she, to begin quickly, and to shew it all to me, as the Man doth the Tombs at *Westminster*; tho' I hope you won't be always in the same haste, nor imitate his precipitant Manner, and aukward Tone of Speech: but do it slowly and distinctly, allowing me time to think and consider about it, and to ask you all the Questions I have a mind to.

MADAM,

MADAM, said I, you know, you can determine and command me, as you please.

This *Silver Plate* on which the Signs of the *Zodiac*, &c. are drawn, represents the Plane of the *Great Ecliptic* of the Heavens; or *that* of the Earth's Annual Orbit round the Sun; which as it passes thro' the Sun's Centre, so its Circumference is made by the Earth's Centre's Motion; and which for the better advantage of View and Sight, is here, you see, placed parallel to our Horizon.

The large *gilded Ball* which stands up, you see, here in the middle, not *upright*, but making with the Plane of the Ecliptic an Angle of about 82 Degrees, is so placed to represent the *Inclination of the Sun's Axis*; and which being pretty near the Centre of this Orbit, represents the Sun.

PRETTY near, said she; why is not the Sun then exactly in the Centre of that Circle which you call the Earth's Orbit?

No, Madam, said I, nor is that Orbit exactly a Circle; but an *Oval* or *Ellipsis*.

As in this Figure which I will now draw with my Pencil and shew you: Let the

Curve Line P O T R

represent the *Orbit* of

the Earth revolving

round the Sun, which

is placed not in C the

Centre, but in S, a

Point in the longer P

Diameter, which they

call the *Focus*: The

Distance between C

and S is what in the *Ptolemaick System*

was called the *Eccentricity*, and expresses

how much the Earth's Orbit differs from

being a true Circle. And the Contri-

vance of this Instrument is so admirable,

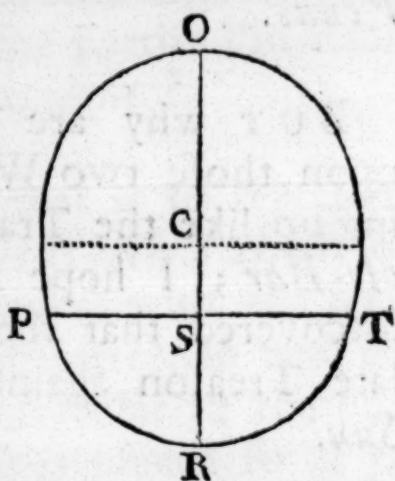
that you will see by and by, when I set

it a-going, this *Eccentricity*, and that of

the other Planets will be plainly shewn to

your Eye, in the same Proportion as they

are in the Heavens.



PRAY, Sir, said she, go on; I find I shall come to understand this better, when I come again to read Dr. Gregory, and Mr. Whiston.

MADAM, said I, you see here two little Balls standing upon two Wires, at different Distances from, but pretty near the

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the

the Sun; the innermost of these is designed to represent *Mercury*, the other *Venus*.

BUT why are they placed, said she, upon those two Wires; they stand perking up like the Traitors Heads upon *Temple-Bar*; I hope Mr. *Rowley* hath not discovered that they have committed any late Treason against their *Sovereign the Sun*.

NO, no, Madam, said I, they are very *Loyal Planets*; the Contrivance is only to bring their Centres to be, sometimes in, and always pretty near the *Plane* of the great *Ecliptic*, (and, by the by, the *Plane* of their Orbit always passes thro' the Sun, and intersects the *Ecliptic* in two Points, which they call *Nodes*) and this Position is contrived in order to shew us what Appearances they do really exhibit in their several Revolutions round the Sun. For the same Reason you see the *Earth* and *Moon* here placed likewise on Wires or Pins, that their Centres may get sometimes actually into, and always be pretty near this *Plane* of the great *Ecliptic*; for so the Orbits of all the Planets are really placed in the Heavens.

I LIKE that *pretty Ivory Earth* very well, said she, as I do the *Golden Sun*: But, pray, why doth the Earth's Pin stand *inclining* so, and not *upright*?

MADAM, said I, that is to represent also the *Angle that the Earth's Axis*, or that of the *Equator*, makes with the Axis of the *Ecliptic*; which latter, in this Instrument, being perpendicular to the Horizon, the Earth's *Axis* is placed so as to make an Angle with the Plane of the Horizon of $66^{\circ}\frac{1}{2}$; or dipping down from the Zenith just $23^{\circ} 30'$, which you know is the Angle made by the two Planes of the Equator and Ecliptic. And as the Earth in each of her annual Revolutions round the Sun, always keeps her own Axis parallel to its self; so you will see, by and by, when the Instrument moves, that this *Terella*, or little *Ivory Earth*, will do so too, as it takes its Tour quite round the *Golden Sun* in this Instrument.

I LONG to see that, said the Lady, very much; but I suppose I must suspend my Inclinations, till you tell me 'tis fit they should be gratified.

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MADAM,

MADAM, said I, 'tis best to consider the several Parts of the Instrument, first separately or singly, and then the several Motions and *Phænomena* will appear in the better and more instructive Light: Therefore if you please, we will go on.

You observe, Madam, said I, *another Wire* here, standing close to this Silver Circle, and which hath a *Ball* upon it, whose Centre is in the Plane of that Circle: This is designed to represent the *Moon*; and the Silver Circle represents her Orbit round our Earth, the Plane of which always runs thro' the Earth's Centre, and the Figures that are engraved upon it, shew her Age, from one New Moon to another.

WELL! said she, this is mighty instructive! I long to see the Earth and the Moon move, but I know I must have patience: I suppose the Moon's Globe being *black* on one side, and *silvered white* on the other, is designed to represent her *Phases*, as they call them, of which you have shewed me something before.

See Fig. 'Tis so, Madam, said I; and you will
of the see this Machine so admirably contrived,
Orrery. that

that what I told you of the Moon's monthly Revolution, will shew itself to be in fact true here; for the *Lunula* here, will turn round its own *Axis*, at the same time as it moves in this *Silver* Orbit round the *Terrælla*. And in reality, Madam, I can't blame your eagerness to see the Machine put into Motion, when I see how well you understand it, and know what it ought to do: And therefore you shall be detained no longer, than while I desire you to take notice of this Hole in the great Brass Plate that covers all the Movement, and of this moveable *Index* here on the silver Ecliptic. You see there are on the former some Figures engraved; they are the common solar *Years*: and by taking the Instrument to pieces, it may be set to this present Time: And the Planets, by means of an *Ephemeris*, may be set to any particular Time also. So that if a Weight or a Spring, as in a Clock, were applied to the *Axis* of the Movement, so as to make it move round once in just 24 Hours, these *Representative Planets*, which you see here, would all perform their Motions round the Sun and one another, exactly in the same Order and regular Manner, as their *Originals* do in the Heavens; and this would then be

Astronomical Dialogues.

a true *Celestial* or *Astronomical* Clock, which would shew the *Aspects*, *Eclipses*, and other *Phænomena* of the Sun and Planets, for ever. But because this would be instructive only in that slow tedious way to such as could have daily recourse to it, Mr. *Rowley* hath contrived, by a *Winch* or *Handle*, to turn the *Axis* swiftly round about, and by that means to shew all the *Phænomena* or *Appearances* in a very little Time, as you shall see I will now proceed to do; for by turning this *Handle* backward or forward, you may see what *Eclipses*, *Transits*, &c. have happened in any Time past; or what will happen for any Time to come, without doing any Injury to the Instrument.

I am amazed at the Thought and Contrivance of this Instrument, said she, and I doubt not shall receive a prodigious Pleasure when I see it put into its proper Motions: But pray, Sir, let me first ask you, *Are all the Planets here?*

No, Madam, said I, (for I see nothing can 'scape your Ladyship's Discernment) here are only shewed the Orbits of *Mercury*, *Venus*, the *Earth*, and the *Moon*; for

for the others, are at too great a Distance to be brought into the Instrument, if any tolerable Proportion be observed between its Parts : And indeed, by what you will see of the Motion of these three Planets, and of the Earth's *Satellite*, the *Moon*, you will easily know what the *Phænomena* of the Superior Planets and of the other *Satellites* would be, if they could be here shewn ; as they cannot well be without embarrassing the Instrument with a vast number of Wheels more : And it hath almost 100 already.

But now, Madam, I will fix on the Handle, and begin to put the Instrument in Motion.

One entire Turn of the Handle answers to the *Diurnal Motion* of the Earth round its *Axis*, as you will see by the Motion of the *Hour Index*, which is placed at the foot of the Wire on which the *Terella* is fixed ; and which you perceive moves once round, as I now with my Hand turn the Spindle of the Machine round, after the same manner. You will take notice also, that the Instrument is so excellently formed, that I can make the Motion tend either way, forward or backward ; and turn it about after the same manner, till I bring the Earth to answer to any Degree

or Point of the *Ecliptic*. As for instance I will move it about till I bring the Earth to the first Point in *Aries*. Then you see, to an Eye placed on the Earth, the Sun will appear to be in the *Opposite Point*, that is, in the first of *Libra*.

BUT, Sir, said she, I perceive as you turn the Earth about, the silver Circle on which the Moon's Age is placed, and which I think you said represented her Orbit, *rises and falls*: What is the meaning of that?

MADAM, said I, you know the Moon's Orbit is not exactly in the Plane of the *Ecliptic*; but makes an Angle with it of between 4 or 5 Degrees: And just so much this Circle rises above and sinks below the great *Ecliptic*, according as the Moon hath North or South *Latitude*, and just as *much* as that *Latitude* is: And you will observe *two little Studs*, which are placed in two opposite Points of this *silver Circle*; they are designed to represent the *Moon's Nodes*, or the Points of Intersection of *her Orbit*, with *that* of the *Ecliptic*: Of which, more by and by,

O!

O ! pray! move on, Sir, said she, this is amazingly fine : I fancy myself travelling along with that little Earth in its course round the gilded Sun, as I know I am in reality with *that* on which I stand, round the *real* one.

Y O U see, Madam, said I, that one entire Turn of the Handle is, as I said before, a Natural Day : Now, if you please to take off *one of the broadest of your Patches*, and make it a *Spot* upon the *Golden Sun* there, you shall see that your Patch will move quite round in 25 Days, or 25 Turns of this Handle ; and that will shew you how by the Motion of the *Spots* in the *real Sun* the Astronomers discover'd he had such a Motion round his *Axis*, as you shall see Mr. *Rowley* hath given here to his *Representative*.

Sun's Motion round his Axis.

W E L L, said she, since even my Patches must become Astronomical, I will stick one upon this *Fictitious Sun* ; but I must own I don't love those *Spots* upon the *Natural* one ; nor to have any of his Face hid, or his Heat impaired : But shew me to what part of the Sun this Patch is to be preferred,

P L E A S E

PLEASE to stick it, said I, Madam, just against the first Degree of *Aries*, and in the middle of the Sun's Body,—
 Very well! Now you will see that as $365\frac{1}{4}$ of these Turns of the Handle will carry the Earth quite round in the *Ecliptic*; *Mercury*. so 88 will make *Mercury* perform his Revolution, and 244 Turns will make *Venus* move quite round the Sun.

Twenty seven Turns and a little more than a quarter of one, you shall see, will carry the *Moon* round in her Orbit; in which time you will observe she always turns the same Hemisphere towards the Earth.
Moon's Periodic Month.

Take notice also, Madam, that now I have just made 12 Turns and an half, which hath carried your Patch to the opposite part of the Sun.

AND shall I ever see it again, said she; shall I ever recover the *Solar Traveller*?

YES, Madam, said I, you may have it again; but pray keep it for hereafter only for such Uses, and don't replace it on your Face; for I am as angry at *Patches* in a good Face, as you are at *Spots* in the Sun; and for your Reason, because

because I would not have any part of it hidden from me.

But the Handle goes on ; a Turn or two more will have carried the *Moon* half round in her Orbit ; observe how she moves : 'Tis now 25 Turns, you see, your Patch is come safe about to you ; off with it.

No, said she, there it shall stick till we have done, since you won't have it be on my Face any more : I love dearly to see it turn round ; and perhaps should I put it on, it may make my Head turn quite round too, as I think it begins to do already without it : but pray turn on your Handle however.

MADAM, said I, at the end of 27 Turns and a Quarter, you see I have made the *Moon* perform her Revolution round the Earth : *Mercury* is got about a third part of his way ; and in 17 Turns more will have finished just half his Revolution. And *Venus*, you see, will then have advanced a fifth part of her way, in proportion to the Magnitude of her Orbit : And the Earth also hath traversed in the Ecliptic the Distance of above three Signs.

And

And by thus revolving the Earth and Planets round the Sun, you may bring the Instrument to exhibit *Mercury*, and sometimes *Venus*, as directly *interposed* between the Earth and the Sun; and then they will appear as *Spots* in the Sun's Disk; as I hinted to you before, *p.* 114. And this Instrument shews also very clearly the Difference between what they call *Geocentric* and *Heliocentric* Aspects, according as the Eye is placed in the Centre of the Earth or Sun.

WELL, said she, I have no words to express the Pleasure and Satisfaction I receive from this most curious Engine, nor the Amazement the wonderful Contrivance of it gives me. Were my Fortune but half as great as my Curiosity, I would have one of these Instruments as soon as possibly I could get it, and then without being beholden to any of you *He-things*, I would turn it about myself, till I made it do all I had a mind to. And I wish now, that I could see the Inside of it; and understand what Numbers of Teeth and Pinions he hath made use of, to produce these various Motions.

MADAM,

MADAM, said I, that can't be done without the Hand of Mr. *Rowley* himself: But our most Excellent King having the same Desire and Curiosity as your Ladyship, he took it all to pieces before his *Majesty*, and to his great Satisfaction shewed him every Part of the Contrivance.

WELL, said she, since I can't have that Satisfaction now, pray proceed to let me know as much of it as you can.

MADAM, said I, you will next be pleased to see the Difference between the Moon's *Periodic* and *Synodic* Month, *Periodic and Synodic Months.* and the Reason of it, very plainly here shewn to the Eye: I have now turned the Handle round till I have shewn you just such a Period, as the Time between our *first* New Moon, when the Earth was in the first Point of *Aries*, and the *present one*: And at the Earth's Place in the Ecliptic, where this happens, I will stick this bit of Paper; and turning $27 \frac{1}{4}$ Turns of the Handle more, you see I have brought the Moon again to be exactly interposed between the Earth and the

the Sun; and then you know it will be *New Moon* to us; but you see the Line of the *Syzygy* is not right against the bit of Paper, but behind it; and it will require two days time, or *two Turns* more, before it will get thither.

I THINK the Reason of that, said she, appears here very plain; because in this 27 Days the *Earth* advances so far forward in her annual Course, as is the quantity of the Difference in Time between the Moon's two Months. But pray, Sir, said she, won't this naturally carry you to shew me how the Eclipses are formed?

YES, Madam, said I, and that is all which is material, that I have left to shew you.

You know, Madam, the Astronomical Books tell you there can be no Eclipse of either Sun or Moon, but when the Moon is in or near the *Nodes*: And this will be here very plainly shewn to you by the means of this Thread, of which if you please to take that End, we will extend it so as to represent the Line of the *Syzygies*: I will turn the Handle about till the next Conjunction of the Moon comes to be in or near the *Node*,
or

or in the Plane of the *Ecliptic*; and then you shall see there will be an *Eclipse of the Sun*. You see I have turned the Handle about 27 times; but now the Centres of the Sun, Earth, and Moon are not near in a Right Line, as the Thread shews you; and therefore there will be no *Eclipse of the Sun*: But you see now at the (a) *Full Moon*, the Line connecting the three Centres, is very near the *Node*; therefore there will be an *Eclipse of the Moon*: And (a) now, ^{(a) After I had turned it round several times till it hapned so.} you see, there is an *Eclipse of the Sun*; which is *Central*, when all the *three Centres* above mentioned come into this Thread thus stretched in the Plane of the *Ecliptic*; and *Total*, when the Moon is in her *Perigæum*, at the greatest Distance from the Sun, and nearest to us.

But in order yet farther to shew the *Solar Eclipses*, and also the several Seasons of the Year, the Increase and Decrease of Day and Night; and the different Length of each in different Parts of our Earth, Mr. *Rowley* hath this further elegant Contrivance.

He hath provided this little Lamp to put on upon the Body of the Sun; which casting, you see, by the means of a *Convex Glass*, and the Room made a little dark,

dark, a strong Light upon the Earth ; will shew you at once all these things : first how *one half* of our Globe is always illuminated by the Sun, while the other *Hemisphere* is in the dark ; and consequently, how Day and Night are formed, by the Revolution of the Earth round her *Axis* ; for as she turns from *West* to *East*, she makes the Sun appear to move from *East* to *West*. And you will please to observe also, Madam, that as I turn the Instrument about in order to shew you the several Seasons of the Year, and the Length and Decrease of Day and Night, how the Shadow of the Moon's Body will cover some part of the Earth, and thereby shew you, that to the Inhabitants of that part of the Earth there will be a *Solar Eclipse*.

THAT is exceeding plain and instructive, said the Lady ; I have taken notice of two or three already, as you have whirled the Earth and Moon round the Sun. But pray for what other End do you thus turn it now ?

ONLY to bring it to shew you the *Autumnal Equinox*, said I, Madam ! and then you will plainly see the Reason
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of the *Equality of Days and Nights* all over the Earth, when she is in that Position.

O! SIR, said she, I thank you; this explains the Figure you drew for me before, by which alone I could not get so distinct and so clear an Idea of the Earth's two Motions, as thus shewn me. But now I see, that as the Earth turns round her *Axis*, just one half of the Equator and all Parallels to it, will be on the Light, and the other half in the Dark; and therefore the Days and Nights must be every where equal: For I see the *Horizon of the Earth's Disk* now lies parallel to the Plane of the *Solstitial Colure*.

EXCELLENTLY well remembred and expressed, said I, Madam. Your Ladyship, I see, hath studied hard since I saw you last in the Country, and we are now sure of you for an Astronomer.

I DON'T know that, said she, 'tis probable I may never take pains enough to go into the *Calculatory Part*; but I think every one should be desirous of knowing the Reason of these common Things we

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are

are now upon, and which happen to us every Year. But pray, Sir, go on, and stop when the Earth comes to be in *Cancer*.

'T IS now got thither, said I, Madam; and you will observe that the *Horizon of the Disk*, or that Plane which divides the Earth's two Hemispheres, the *Enlightened* from the *Dark* one, is now no longer *parallel* to, but lies at *right Angles* to the *Plane* of the great *Solstitial Colure*: The Earth being now in *Cancer*, the Sun will appear to be in *Capricorn*; and consequently it will be our *Winter Solstice*. And you see plainly, that as I keep turning the Earth round its Axis either way, the entire Northern frigid Zone, or all Parts of the Earth lying with the Artick Circle, are in the Dark Hemisphere; as you see by this little bit of Wafer, which I stick upon the Circumference of that Circle.

Your Ladyship will observe also, that now I remove that *bit of Wafer*, and place it in the Circumference of that Circle which exhibits the *Path of the Vertex of London*, how much *Longer*, in a Diurnal Revolution of the Earth, *that* will be in the *Dark*, than in the *Light*:
Just

Just such is the Disproportion of our Days to our Nights at that time ; scarce a third Part.

I SEE this thing, said she, exceeding plain ; and also that the Inhabitants of our *North Pole*, if any such there are, have not seen the Sun since the 12th of *September*.

No, nor can't again, said I, Madam, till the Vernal Equinox ; for all this six Months they must be condemned to perpetual Darkness : Only the Sun never being above $23\frac{1}{2}$ Degrees below their Horizon, and the most of the time not above 10 or 12 ; the Sun, by his shining on their Atmosphere, reflects them such Light as we have about half an Hour after Sun-set : Also they have Moon-Light for half of the time, so that both these added together, it is not so very Dark with those at either Pole, during the Absence of the Sun, as at first you imagined. But pray observe, Madam, that as I move the Earth along in its Orbit, till it come thither, how the *Nights shorten*, and the *Days lengthen*, by Degrees, till they come then to an Equality again on the 10th of *March* ; when our Earth being in the

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first of *Libra*, the Sun must appear to be in the first Degree of *Aries*. And now the *Earth's Axis*, which you see always keeps parallel to it self, will come again to be in the Plane of the *Horizon of the Disk*, and consequently the Equator, and all its *Parallel Paths* will be *bisected* by that *Horizon* in every Diurnal Revolution of the Earth; or there will be an *universal Equinox* all over the Globe.

THIS, said the Lady, is indeed seeing into the very bottom of the Matter, and understanding it from its Causes and Original. But pray, Sir, turn about your Handle again; and get me our dear Northern Pole out of the Dark, as I see it will soon be, and then I hope it will enjoy the Benefit of six Months cheering Day, as it hath had a melancholy half Year's Darkness.

THAT it will, Madam, said I; and now you will observe with pleasure, how the *Days Encrease*, and the *Nights Decrease*, as the Earth moves on towards *Capricorn*, where now I will stop it; while you observe that all the *Polar Circle* is got into the enlightned Hemisphere; as also above two parts in three of the

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Path

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Path of London (h L m f) in Fig V.
and therefore now our Days are at *Longest*,
this is our *Summer Solstice*, or *Midsummer*.

YES, said she, I see it, and understand it perfectly well : But I see withal, that our Days, now at their greatest extent, are going to shorten again, which I will bear as long as I can, that is, till you wheel the Earth about again into *Aries* : But then, if you please, we will leave off, having attended upon the Earth in one entire Revolution round the Sun ; and most demonstratively and delightfully seen, how thereby all the *Phænomena* of the different Seasons of the Year, and the Varieties and Vicissitudes of Night and Day are solved and accounted for.

Pray, when you see Mr. *Rowley*, thank him from me, for this most noble and intellectual Entertainment.

Claudiani Epigr. xiii. In *Sphæram*
Archimedis.

Jupiter in parvo cum cerneret Æthera Vitro
Risit, & ad Superos talia dicta dedit :
Huccinè mortalis progressa Potentia Curæ ?
Jam Meus in fragili luditur Orbe labor !

Jura

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*Jura Poli, rerumq; fidem, Legesq; Deorum
Ecce Syracusius transtulit arte Senex !*

*Inclusus variis famulatur Spiritus Astris,
Et Vivum certis Motibus urget Opus !
Percurrit proprium Mentitus Signifer Annum
Et simulata novo Cynthia mense redit !*

*Jamq; suum volvens audax Industria Mundum
Gaudet, & humanâ sidera mente regit,
Quid falso insontem tonitrue Salmonea * miror.
Æmula Natura parva reperta Manus.*

Thus imitated and applied to Mr. Rowley's
O R R E R Y.

*When lately Jove the ORRERY survey'd,
He smiling thus to Gods in Council said ;
How shall we stint presuming Mortals Pow'r ?
The Syracusian Sage did, once before,
The heavenly Motions shew in Spheres of Glass,
And the Erratick Orbs and Stars express :*

But

* *Salmonius* King of *Elis*, by driving a Chariot over a Brass-Bridge, dared to imitate Thunder, for which *Jove* flew him with a Thunderbolt ; for thus *Virgil*, *Æn.* 6. speaks of him,

*Vidi & Crudeles dantem Salmonea pœnas,
Dum Flammas Jovis, & sonitus imitatur Olympi.*

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*But his Machine by one fixt Pow'r and Weight,
Mov'd, and was govern'd, as we are, by Fate.
While the bold Rowley in his Orrery
Keeps his first Pow'r, just like his Genius, free :
He knows the secret Springs ; and can impart
Laws to the whole, and to each single part ;
His daring Hand, or brings or hinders Fate,
Makes Mercury fly, or Saturn walk in State :
He makes the Earth thro' silver Zodiac run
Justly obsequious to the Golden Sun :
While the bright Moon shining with borrow'd Light,
Marks out the Months, and rules the Sable Night.
And all obedient to his sole Command,
Turn round their Axes, as he turns his Hand :
Their Phases and their Aspects all display,
And at his beck, exhibit Night or Day :
He makes Eclipses, as he will, appear,
For any past, present, or future Year ;
Shews their true Cause, and roots out vulgar Fear. }
Guiltless Salmoneus at your Suit I slew,
Shall I, to please you, take off Rowley too ?
O ! no ! all cry'd ; the glorious Artist spare ;
Transplant him hither, and make him a Star.*

This

This famous Sphere of *Archimedes* is mention'd by *Cicero* and by *Ovid* : and the *former* saith, that it shewed the Motion of the Sun, Moon, and Planets. *Pliny* tells us, that *Atlas* and *Anaximander*, both made such a Sphere; as *Diogenes Laertius* saith *Musæus* also did. *Sextus Epiricus* saith it was made of Wood; and *Cælus Rhodiginus*, that it was of Brass.

F I N I S.



